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REPORT

ON THE

SCIENTIFIC RESULTS

OF THE

VOYAGE OF S.Y. "SCOTIA"

SCOTTISH NATIONAL ANTARCTIC EXPEDITION.

REPORT

ON THE

SCIENTIFIC RESULTS

OF THE

VOYAGE OF S.Y. "SCOTIA"

DURING THE YEARS 1902, 1903, AND 1904,

UNDER THE LEADERSHIP OF

WILLIAM S. BRUCE,

LL.D., F.R.S.E.

Volume III.—BOTANY.

PARTS I.-XI.—By R. N. RUDMOSE BROWN, D.Sc.; C. H. WRIGHT, A.L.S.; O. V. DARBISHIRE, B.A., Ph.D.; JULES CARDOT; A. GEPP, M.A.; E. S. GEPP; E. M. HOLMES, F.L.S.; M. FOSLIE; F. E. FRITSCH, D.Sc., Ph.D.; J. H. HARVEY PIRIE, B.Sc., M.D., F.R.C.P.Ed.

Twelve Plates and a Chart.

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EDITORIAL NOTE.

THE author of *Flora Antarctica* and the pioneer of botanical research in the Antarctic regions has passed away just as this volume was going to press. Our desire, therefore, to dedicate it to him can no longer be fulfilled, nor can we look forward, as we had hoped to do, to his friendly criticism of our efforts in this branch of our researches in high southern latitudes.

To Dr R. N. Rudmose Brown have fallen practically all the editorial duties, while little more than publisher's duties, made light by Dr Brown's excellent editing, has fallen upon me. Dr Brown is also the author of Part I., "The Problems of Antarctic Plant Life." He is, with Dr Darbishire, joint author of Part II., "The Botany of the South Orkneys"; and with Dr Darbishire and Mr C. H. Wright, author of Part III., "The Botany of Gough Island." Part IV., "Contributions towards the Botany of Ascension," we also owe to him. It has been an exceptional chance that three of us who worked together in the field have been able to co-operate in the production of this Report—Dr J. H. Harvey Pirie, who was bacteriologist to the *Scotia*, contributing Part X., "Antarctic Bacteriology."

My cordial thanks are due not only to Dr Rudmose Brown and Dr Harvey Pirie, but also to Dr O. V. Darbishire, Mr C. H. Wright, M. Jules Cardot, Mr and Mrs Gepp, Mr E. M. Holmes, the late Mr M. Foslie, and Dr F. E. Fritsch. All these have made important and valuable additions to the late Sir Joseph Hooker's *Flora Antarctica*.

It is unfortunate that the Report on the Phytoplankton is not ready to include in this volume, but the rest of the contributions have been already too long delayed for lack of funds; that Report, in consequence, must stand over for a future volume.

WILLIAM S. BRUCE,
Editor.

EDINBURGH, *March* 1912.

INTRODUCTION.

The botanical results of the Scottish National Antarctic Expedition deal principally with the South Orkney Islands and with Diego Alvarez or Gough Island. From neither of these islands had we any botanical knowledge before the visit of the *Scotia*.

The South Orkneys were visited twice during the summer, in February 1903 and February 1904, and at Scotia Bay in Laurie Island the *Scotia* spent the winter of 1903. Numerous opportunities thus presented themselves for making collections of the scanty flora of Laurie Island.

On Gough Island the naturalists of the *Scotia* were able to spend only a few hours ashore on one day, and on that occasion it was impossible to go far inland out of touch with the ship, since the weather conditions were such as to promise a hasty recall. Consequently the collections from Gough Island are in no direction exhaustive.

No landing was made on Coats Land, which the expedition had the honour to discover, since none was possible, owing to the lateness of the season and the threatening nature of the heavy pack in which the *Scotia* was beset.

The marine algæ of the Weddell Sea were most extensively collected through fully 10,000 miles of previously unexplored waters, not to speak of the collections made from Madeira to the Falkland Islands, and from Cape Town to the Azores. The Report on the Phytoplankton will be published later. Dr Harvey Pirie has added the results of his bacteriological work.

A few notes of value on the botany of Ascension are included, based on collections made on the homeward voyage of the *Scotia*.

On an expedition primarily equipped for oceanographical exploration, a botanist cannot look for great opportunities beyond the study of phytoplankton, and it is with great pleasure that I look back on the invariable thoughtfulness and help of my leader, Dr W. S. Bruce, whenever an occasion for botanical work presented itself. I would take this opportunity of recording my thanks to him and to my colleagues of the Scottish National Antarctic Expedition for the generous assistance they gave me in furthering and in sharing my work on the expedition.

Accounts of the greater part of the botanical collections of the Scottish National Antarctic Expedition have appeared at various times in different botanical publications. From these publications they are reprinted, in many cases with additions and alterations, in the present volume. The following is a complete list of the original papers and their place of publication :—

Brown, R. N. Rudmose, "The Botany of Gough Island: I., Phanerogams and Ferns," *Journ. Linn. Soc. Lond., Bot.*, xxxvii. pp. 238–250. Plates.

—— "The Botany of the South Orkneys: I.," *Trans. and Proc. Bot. Soc. Edin.*, xxiii., part i. pp. 105–110.

—— "Contributions towards the Botany of Ascension," *Trans. and Proc. Bot. Soc. Edin.*, xxiii. pp. 199–204.

Cardot, Jules, "Les Mousses de l'Expédition nationale antarctique écossaise," *Trans. Roy. Soc. Edin.*, xlviii. pp. 67–82. Plates.

Darbishire, O. V., "The Botany of Gough Island: II. Lichens," *Journ. Linn. Soc. Lond., Bot.*, xxxvii. pp. 266–267.

—— "The Lichens of the South Orkneys," *Trans. and Proc. Bot. Soc. Edin.*, xxiii., part i. pp. 108–110. Plate.

Foslie, M., "Calcareous Algæ," *Kongl. Norske Vidensk. Selsk.*, Trondhjem (1904), p. 3.

Fritsch, F. E., "Freshwater Algæ collected in the South Orkneys," *Journ. Linn. Soc. Lond., Bot.*, xl. pp. 293–338.

Gepp, A. and E. S., "Antarctic Algæ," *Journ. Bot.*, April 1905 and May 1905. Plate.

—— "More Antarctic Algæ," *loc. cit.*, July 1905. Plate.

—— "Atlantic Algæ of the *Scotia*," *loc. cit.*, April 1905.

Holmes, E. M., "Some South Orkney Algæ," *Journ. Bot.*, July 1905.

Wright, C. H., "The Botany of Gough Island: II. Mosses and Hepatics and Fungi," *Journ. Linn. Soc. Lond., Bot.*, xxxvii. pp. 264, 265.

—— "The Mosses of the South Orkneys," *Trans. and Proc. Bot. Soc. Edin.*, xxiii., part i.

(*Note.*—The two papers by Mr Wright on the mosses are not republished in the present volume, since Monsieur Cardot has redetermined the mosses of the *Scotia*, and has entirely superseded previous papers on the subject.)

I have taken advantage of the occasion of the republication of these papers to ask the various authors to bring them up to date in the light of the most recent research, and I have added a general discussion of the problems of Antarctic botany.

My thanks are due for valuable assistance to the following who have collaborated with me in the work of describing the *Scotia* botanical collections:—Monsieur Jules Cardot, Dr O. V. Darbishire, the late Mr M. Foslie, Professor F. E. Fritsch, Mr A. and Mrs E. S. Gepp, Mr E. M. Holmes, and Mr C. H. Wright. I would also record my thanks to Sir W. T. Thiselton-Dyer, K.C.M.G., late Director of the Royal Botanic Gardens, Kew, for permission to make use of the Kew Herbarium; to Mr W. B. Hemsley, F.R.S., and Professor J. W. H. Trail, F.R.S., for advice on certain points; and to the Societies in whose publications certain of these papers originally appeared, for permission to reprint.

It had been intended to dedicate this volume on Antarctic botany to Sir Joseph Dalton Hooker, the earliest pioneer of botanical investigation in South Polar lands and seas. His death on December 10, 1911, has prevented this; so all that can be done is to offer these papers as some slight tribute to the memory of that great man.

R. N. Rudmose Brown.

Edinburgh, *March* 1912.

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I.—THE PROBLEMS OF ANTARCTIC PLANT LIFE.

I.—THE PROBLEMS OF ANTARCTIC PLANT LIFE.[1]

By R. N. Rudmose Brown, D.Sc., University of Sheffield.

(*With a Chart.*)

The general belief held until quite recent years that the Antarctic regions were almost destitute of botanical interest and the last place on the earth's surface where plants could be looked for, was amply justified until the closing years of last century. Our botanical knowledge of these regions up to that time was so scanty that almost the only collections known were the few mosses from Cockburn Island, Graham Land, found by Joseph Hooker in Ross's expedition in the *Erebus* and *Terror* in 1839–43.

The recent renewed interest in the Antarctic, as expressed in the expeditions of the last decade, by various collections and observations, has shown that the south polar flora, poor as it may be, is nevertheless in some respects richer than was supposed, and gives the botanist reason to hope for further results from future expeditions. One of the chief interests in these collections lies, of course, in the questions they give rise to in the problems of geographical distribution, and the origin of the Antarctic flora.

It is much to be hoped that future expeditions will make further discoveries in palæobotany. With the exception of a somewhat doubtful fossil of coniferous wood, that may be ascribed to Lower Carboniferous or Devonian times, found in Victoria Land, the only fossil plants we know from Antarctica are the abundant remains brought back by Dr Otto Nordenskjöld from Hope Bay in north-east Graham Land. This flora of ferns, cycads, and conifers indicates a warm, moist climate and abundant vegetation in Jurassic times. The fossil *Araucaria*, *Fagus*, and other plants found at Seymour Island by the same expedition, indicate an extension of these conditions into Tertiary times.

The adaptations of the various species to their environments, a study particularly important in the case of cosmopolitan species, promises most valuable results, but is more likely to be undertaken seriously when the systematic and geographical interests of the flora have been more fully worked out. For a newer study almost invariably has to wait until the older aspects of the science have been satisfied. It is, moreover, extremely desirable that such physiological and morphological questions should be studied on the spot; indeed, the impracticability of satisfactory investigation in any other circumstances is most obvious. Dr Fritsch in his remarks on yellow and red snow (pp. 99–120 of this volume) speaks of the absolute necessity of investigating these

[1] Certain parts of this article appeared in a less extended form in a previous paper by the same author, "Antarctic Botany: its Present State and Future Problems," *Scot. Geog. Mag.*, 1906, pp. 473–483.

occurrences in the field. The difficulty of laboratory accommodation in the isolated Antarctic regions is naturally great, but not nearly so great as is generally supposed. Various expeditions which have recently wintered in the south have shown that the climatic conditions, though not exactly as favourable as in the north, offer no serious inconvenience to an ordinary robust constitution and cheerful disposition, even though one is not prepared to rough it in the manner of the geographical explorer. And, furthermore, it should be remembered that there are at the present time several habitable dwellings within the regions of south polar ice which have been erected by one or other of the expeditions of the past ten years. Of these the house at Scotia Bay, South Orkneys, is permanently inhabited as an Argentine Meteorological Observatory, while that at Wandel Island has been, or shortly will be, taken possession of for a similar purpose. Thus it will be seen that laboratory accommodation on a small scale in the Antarctic regions is far from impracticable, and should not be a matter of any very great cost. Most of these stations, it may be remarked, are not very far to the south; but that is a distinct advantage, for while all are within the veritable polar regions and experience the real Antarctic climate, they escape in very large measure the long night and its attendant drawbacks, and, most important consideration of all, they are readily accessible, so that a relieving ship should experience little difficulty in gaining all or any of them every summer. The Danes have now established in north polar regions, on Disco Island, a fully equipped biological laboratory, and the extreme desirability of a similar station in south polar regions need not be further urged. But in the meantime, until this larger project can be put into execution, it would be most desirable that a biologist should be attached to each of these Antarctic observatories, year by year, though, of course, as the number of inhabitants at each observatory must be very strictly limited, he would combine his biological studies with the duties of a meteorological observer.

The most striking feature of the Antarctic flora is, of course, its poverty compared with that of the Arctic. Thus the Arctic regions support about four hundred species of flowering plants, while the Antarctic regions support but two, and even these can hardly be said to flourish. The reasons which bring about this extreme contrast between north and south is one of the most interesting biological problems that awaits solution in these regions.

The amount of light available is, of course, the same in north and south at corresponding latitudes, and yet the contrast between the two vegetations is even more marked when one remembers that in Spitsbergen, in 79° N., the ground is bright in summer with a hundred species of flowering plants, while at the South Orkneys, in only 61° S., there is not a single species. In Grant Land, in 81°–82° N., in three localities, Peary collected 57 mosses and 7 hepatics—a greater number than at present known from the whole of the Antarctic regions south of 60° S.[1] Snow is probably not much more

[1] "Ad cognitionem Bryophytorum arcticorum contributiones sparsæ," M. Bryhn, *Vidensk. Selsk. Fordhandl.* (Christiania), 1908, No. 5.

abundant in the south, and winter temperatures, at least in the outermost south polar regions, neglecting for the moment comparative latitudes, are not more severe than in the north.

The real explanation is probably to be found in the short and inadequate Antarctic summer, with its remarkably low temperatures. Thus, for example, at the South Orkneys, in 60° 44′ S., the mean of the summer months (December, January, and February) is barely 32° F., and in no month does the mean rise to 33° F., while the mean of the warmest day in 1903–04 was only 37·7° F.; at Snow Hill Island, Louis Philippe Land (64° 24′ S.), the mean of the warmest month (January) was found to be only 30·38° F., while at Cape Adare, Victoria Land, in 71° 18′ S., the summer mean is 30·4° F.

At 77° 50′ S., 166° 44′ E., in McMurdo Sound, the *Discovery* found that the mean summer temperature was 21·4° F., and the mean of the warmest month, December, was 24·6° F.

These temperatures may be compared with those of the Arctic regions. Thus at Spitsbergen (79° 53′ N.) the mean temperature of July (the corresponding month to January in the south) is as high as 41·5° F., while in Franz Josef Land, in over 80° N., it is not lower than 35·6° F. in the same month. The mean of the Spitsbergen summer (June, July, and August) is 37·1°, contrasted with the corresponding mean given above for the South Orkneys, scarcely 32° F. Examples could thus be multiplied, but all would bring out the same important point—that while the Arctic summer mean is well above 32° F., the Antarctic summer mean is practically always below. This remarkably cold Antarctic summer acts in two ways upon plant life: firstly, the winter snow lies late on the ground—all the later as the summer is a cloudy and somewhat sunless period, and December is well advanced before the majority of available sites are laid bare, while in February the winter again begins [1]; secondly, and this is the chief reason, it is doubtful if a flowering plant could obtain the requisite amount of heat needed for its various life functions even to reach the flowering stage, while the maturation of its fruit would be next to impossible. In fact, one could with much truth say that the Antarctic summer is but an astronomical conception: those who have experienced it know well how little reality it has. Doubtless, then, in this want of a season of growth lies a quite adequate explanation of the poverty of the south polar vegetation, but I think that there is also another adverse influence at work. Even supposing that a species did obtain a footing on Antarctica, as is not impossible in the lands nearest Fuegia, considering the narrowness of Drake Strait, its continued existence would be at once menaced by the presence of the myriads of penguins which occupy almost every bare spot of ground during the nesting and breeding season. There is no parallel in the north to these penguins and the power they would have in destroying any vegetable

[1] Contrast this with the north, where, for example, at the northern part of the east coast of Greenland, the land is clear of snow from May or early June until September, dates which would correspond in the south to November to March.

life. Almost every spot where a plant might obtain a hold is covered with these birds in the proportion of at least one to a square yard, and nothing escapes their insatiable curiosity or fails to be examined with their beaks, while in a few weeks' time such a rookery is in an indescribable state of filth, being entirely covered with several inches of mud and manure through which the penguins are incessantly tramping hither and thither; circumstances which would render plant life quite out of the question. It is true that here and there one finds a small expanse—even as much as an acre I have once seen—of moss-covered rocks which by successive years' growth are covered with 6 to 8 inches of vegetable soil, but these are spots much less accessible from the sea, and are very seldom suitable for rookeries—which is, of course, the sole condition under which this continuous growth of moss from year to year could continue. In such spots one might look, though in vain, for flowering plants, and perhaps in consequence conclude that the influence of the penguins, though potentially inimical to vegetable life, has never cause to operate, at least against flowering plants. But it must be noted that these moss formations, though in many respects suitable for phanerogamic plant life, are yet always very late in losing their winter snow, and generally lie in sheltered places where wind-carried seeds would be little likely to arrive. That seeds of Fuegian species of phanerogams occasionally reach Graham Land and the adjacent South Shetland and South Orkney Islands is more than probable, considering the prevalence of winds from the north of west in that region: it is even possible, though far less likely, that wind-carried seeds from Kerguelen and Heard Islands occasionally alight on parts of the coasts of Wilkes Land. Most important in relation to the possible wind transport of Fuegian species to Antarctica is the discovery by Dr F. E. Fritsch of pollen grains of *Podocarpus* among the algæ found in a patch of red snow in the South Orkneys. The nearest land from which these pollen grains could have come is southern South America, where several species of *Podocarpus* occur in Chili, some at high altitudes, and so more likely to have their pollen carried by the wind. I cannot suggest any way in which these pollen grains can have reached the South Orkneys other than by wind carriage, and their presence seems indisputable proof of the possibility of this occurring. In this relation it is noteworthy that Dr Fritsch believes "that the nature of some of the Antarctic freshwater plankton points to wind carriage over considerable distance, although the available data are not sufficient."

The likelihood of the transport of seeds by birds is lessened by the fact of there being only one true land bird (*Chionis alba*) in the Antarctic, but it seems quite probable that seeds and spores are occasionally carried adhering to the feet and feathers of such wandering birds as the southern black-backed gull, the skua, and the giant petrel, which range from sub-antarctic to Antarctic lands. Almost everywhere that snow-free land occurs on the coasts of Antarctica in summer, innumerable birds find nesting-places, and these are the places where or near where most of the vegetation occurs. As regards floating ice, I do not think that in the Antarctic it ever acts as an agency in the dispersal of species.

It has been suggested that the conspicuous absence of driftwood on Antarctic shores shows that there is little likelihood of wave-carried seeds being stranded.[1] The contrast with the shores of some parts of the Arctic regions is certainly great in this respect. Numerous stretches of the coasts of Spitsbergen have almost the appearance of timber-yards with their acres of timber-stacked beaches. During eight months at the South Orkneys we found only a single small piece of driftwood. But this absence of driftwood can be explained on two grounds: firstly, to currents sweeping past rather than striking the shores of Antarctica, except perhaps the north-west of Graham Land and the South Shetlands; and, secondly, to an absence of driftwood in the waters of the Southern Ocean.

Most of the Arctic driftwood is brought down by the Siberian rivers and the Mackenzie River in flood. A large amount is thus swept into a confined sea. For the Southern Ocean there are no such sources of supply, while the little timber that is swept into the sea is negligible in that vast extent of water. Nor do I think that seeds and spores brought on driftwood and wreckage to Antarctic coasts would stand any chance of stranding on a locus favourable for growth, even supposing they had survived the voyage, and that is most unlikely.

It is therefore not by reason of their isolation alone that the south polar regions have next to no phanerogamic vegetation, but because they are unsuited in one way or another to support it. If such a modest biological station, as I have advocated above, should be instituted, it would be a matter of extreme interest to attempt to cultivate on certain of the mossy oases various species of hardy Arctic plants, such as *Papaver radicatum, Ranunculus sulphureus, Cerastium alpinum, Saxifraga oppositifolia*, etc. etc., which all prosper and produce seed in Spitsbergen.[2]

Dr Skottsberg, of the Swedish Antarctic Expedition, considers that the formidable Antarctic winds must be another unfavourable condition for higher plant life.[3] While fully admitting the strength of the winds that sweep over certain localities the greater part of the year, I do not think that they could have an inimical influence on any possible vegetation, partly because there are always certain sheltered spots, but largely because the Antarctic summer is a relatively calm period, while the winds of winter could of course have no prejudicial influence through the covering of snow.

[1] *Polar Exploration*, W. S. Bruce, London, 1910, p. 92.

[2] On my return from the Antarctic in 1904 I attempted to make such an experiment by sending to the Argentine Meteorological Station at the South Orkneys a supply of seeds of 22 Arctic species of phanerogams, with a request to have them planted in a certain spot which I chose as suitable during my stay at Scotia Bay in 1903. I understand that all the seeds that were planted failed to sprout, but the absence of a biologist on the spot may have militated against the success of the experiment. The seeds sent were all of Arctic species, and it may be as well to publish the complete list, which is as follows:—*Papaver radicatum*, Rottb.; *Draba alpina*, L.; *D. hirta*, L., f. *rupestris*, R. Br.; *Cochlearia officinalis*, L., var. β, Vahl; *Vesicaria cretica*, Poir.; *Silene acaulis*, L.; *Cerastium alpinum*, L.; *Potentilla nivea*, L.; *Alchemilla alpina*, L.; *Saxifraga oppositifolia*, L.; *S. nivalis*, L.; *S. rivularis*, L.; *S. hypnoides*, L.; *Rhodiola rosea*, L.; *Erigeron alpinum*, L., var. *grandiflorum*, Rahl.; *Hieracium alpinum*, L.; *Vaccinium uliginosum*, L.; *Arctostaphylos uva-ursi*, Spreng.; *Armeria pubescens*, L.; *Oxyria reniformis*, Hook.; *O. elatior*, R. Br.; *Luzula spicata*, Desv.

[3] "On the Zonal Distribution of South Atlantic and Antarctic Vegetation," Carl Skottsberg, *Geog. Journ.* Dec. 1904.

Before turning to a consideration of the actual vegetable life of the Antarctic, especially as revealed by the expeditions of the last few years, it would be advisable to define the limits of the Antarctic regions from a phytogeographic standpoint. On this subject there has been much diversity of opinion, largely attributable to an almost complete ignorance of the conditions obtaining in the south.

In an able discussion [1] of the whole question, Dr Skottsberg clearly points out the obvious error that phytogeographers commit in placing the boundary of the Antarctic regions too far to the north so as to include, according to some, even part of South America: as untenable a position as that of those who would restrict the Antarctic to the regions south of the astronomical Antarctic circle. Dr Skottsberg shows that the parallel of 60° S. forms a more or less natural limit, and in this proposition of his I quite agree. The South Orkneys without a doubt are truly Antarctic in all respects, but South Georgia is sub-antarctic, and so in all probability is the South Sandwich group.

The flora of the Antarctic regions as thus defined contains only two phanerogams, viz. *Descampsia antarctica* (Hook.), Desv., and *Colobanthus crassifolius*, Hook. f. var. *brevifolius*, Eng. The former of these has long been known from Antarctic regions, having been collected by Eights about 1820 at the South Shetlands, and it also occurs on several parts of Graham Land; but its discovery, along with *Colobanthus crassifolius*, by Dr Turquet, of the French Antarctic Expedition (1904–05), at Biscoe Bay, Anvers Island, in 64° 50′ S., 63° 40′ W., was very interesting, for this was the most southerly record for flowering plants known. *Descampsia antarctica* was also found by Dr Turquet at Wandel Island, 65° 4′ S. Dr Charcot's expedition in the *Pourquoi Pas?* in 1910 found these two species of flowering plants as far south as 68° S. Both these phanerogams occur also in Fuegia, the Falkland Islands, and South Georgia. Reference has been made by me elsewhere [2] to the reputed grass of the South Orkneys, of whose occurrence we have no evidence except the vague report of a sailor, and which I know from personal search does not grow to-day in the place indicated.

Ferns are entirely wanting in the Antarctic, as was only to be supposed, but mosses are relatively abundant and form almost the chief constituent of the flora. Collections [3] of these are known from various points around the pole, including Graham Land, South Shetlands (*Belgica*, *Antarctic*, *Français*, and *Pourquoi Pas?*), South Orkneys (*Scotia* and Argentine Expedition), Wilhelm Land (*Gauss*), and Victoria Land (*Southern Cross*, *Discovery*, and *Nimrod*), but those from the Atlantic and American sides are incontestably the richer, no doubt largely because of the nearer proximity of extra-polar land and consequent possibility of migration, but also to some extent because that side of the

[1] "Some Remarks upon the geographical distribution of vegetation in the colder Southern Hemisphere," Carl Skottsberg, *Ymer* (Stockholm), 1904, pp. 402–427. This paper also contains a useful bibliography of Antarctic and sub-antarctic botany.

[2] See this volume, p. 24, and "The Botany of the South Orkneys," R. N. Rudmose Brown, *Trans. and Proc. Bot. Soc. Edin.*, xxiii. i. (1904–05).

[3] See paper by J. Cardot in this volume, pp. 55–69, and "La flore bryologique des Terres magellaniques de la Géorgie du sud et de l'Antarctide," J. Cardot, *Wissen. Erg. Schwed. Südpolar-Exp.*, iv. 3.

Antarctic regions has received more careful and serious exploration than any other. Graham Land, moreover, extends to a far lower latitude than other parts of Antarctica.

The total number of mosses brought from Antarctic regions up to and including the collections of the *Nimrod*, appears to be 52. The *Belgica* collected 27 species on the west of Graham Land, the *Antarctic* 23 in different parts of Louis Philippe Land and adjacent regions, the *Français* 18 round about Gerlache Strait, and the *Scotia* 10 at the South Orkneys. Four further species were collected at the South Orkneys by Señor L. H. Valette of the Argentine Observatory (1904). Of the 14 South Orkney species none are endemic, but 4 are not known from outside the Antarctic regions. The *Southern Cross* collected 3 species in Victoria Land, the *Discovery* added 6 further ones to this list, and the *Nimrod* one more. The *Gauss* collected only one species of moss at Wilhelm Land, and this at present is the only one known throughout the whole extent of coast-line between Cape Adare and Graham Land. The Scottish Expedition was unable to effect any landing on Coats Land.

Dr Cardot has recently discussed in full the relationships of the moss flora of the Antarctic (*loc. cit.*). He points out that 24 of the 52 species are endemic, 16 are northern and 12 southern species of wide distribution, while the rest are more or less cosmopolitan; and noting also that many Antarctic species have close affinities with northern species, concludes that "en somme la facies de la flore bryologique antarctique est plus boréal que magellanique." Dr Cardot believes that the Antarctic moss flora will be found to be very uniform wherever it occurs. Of the 9 species known from Victoria Land, 5 are peculiar to Antarctic regions, and 3 of those are also found in Graham Land. In all, 6 of the 9 species found in Victoria Land are common to both it and Graham Land: this is a high proportion.

Again, the relationship of the Antarctic moss flora with those of South Georgia and the Magellan lands is most noticeable. There are 17 species common to the Antarctic and South Georgia, of which 6 are of wide distribution in other lands, chiefly northern: 16 species are common to the Antarctic and Fuegian lands, of which 10 are of wide distribution, again chiefly in the northern hemisphere. Excluding 8 species of wide distribution, only 5 species occur in both the Antarctic and Kerguelen, and of these 3 are also found in South Georgia. These facts suggest a migration from Fuegian lands as the origin of the Antarctic flora.

The life conditions for mosses are evidently not too unfavourable, for most of the species show a fairly vigorous growth and do not appear to suffer from the severe environment. Dr Cardot comments on the luxurious growth of certain specimens submitted to him. This can specially be remarked in those species which have a wide distribution throughout other parts of the world, for in them it is possible to make a comparison of the effects of the Antarctic climate and soil on the growth of the plant. In the South Orkneys I noticed that for at least seven months, and in places eight, the moss was frozen as hard as rock, but this did not seem at all to impair its vitality on the return of spring: farther south—and mosses have been collected in the far south of Victoria Land (78° S.)—their frozen condition must last longer. In this relation it is striking how poor and stunted are the specimens from 77° to 78° S. in Victoria Land compared to those from lower latitudes in Graham Land. Vegetative reproduction among Antarctic mosses seems to be the rule, and fruiting specimens of most species are very rare among the collections of all the expeditions: among my South Orkney specimens the only species with many and well-developed fruits was *Polytrichum subpiliferum*, Card., and Dr Cardot says that among all the species of Antarctic mosses he has seen only 6 in fruit: in a few other species "flowers" have been seen.

Antarctic mosses generally grow in small colonies in which a number of different species may be found together. In the midst of these clumps an occasional hepatic may be found, for hepatics seldom if ever grow isolated, nor indeed do individual species of moss. Doubtless this is the only habitat in which hepatics with their more delicate tissues could survive. In some cases a small tundra of moss and lichen vegetation may be formed, and since these tundras are used as nesting-places by skuas and gulls, while other birds, as shags, build their nests largely of moss and lichen, one can understand the dispersion of the flora by this agency. This habit of aggregation which Antarctic mosses have, shows the need of exhaustive collecting: a mere sample or two of a clump is not sufficient, and a collector new to the Antarctic will invariably overlook many species by not taking numerous enough samples of each colony.

The number of Antarctic hepatics is naturally not great, and includes not more than 6 species, of which 3 are found in Gerlache Strait, 1 at the South Shetlands, and 3 in Orleans Channel. In the South Orkneys no species was discovered, nor was any found in Wilhelm Land or Victoria Land. Of these 6 hepatics, 4 occur in South Georgia. While several fungi are recorded from sub-antarctic islands, such as Tristan da Cunha, Gough Island, and others, the true Antarctic regions support but a single species, the discovery of which was made by M. Racovitza of the *Belgica*; this was a new species, *Sclerotium antarcticum*, Bomm. et Rous., and was found on Danco Land growing among *Aira antarctica*: apparently this is its only record.

Undoubtedly the predominant feature of the Antarctic vegetation is the number of lichens, not as species, but as individuals. At the South Orkneys the lichen vegetation is very rich. In winter, when almost everything is deep in snow, a few precipitous rock faces still show a relieving touch of colour among the monotonous white, due largely to various orange-coloured species of *Placodium* (*P. regale*, Wainio, and *P. elegans*, Nyl.): when the snow begins to melt in spring almost all the rocks bared to view show a shaggy covering of *Usnea melaxantha*, Ach., a species which more than any other seems to luxuriate in the conditions of life to be found there, and produces good "fruits" in quantity. Dr Skottsberg also mentions the frequency of *Placodium* and *Usnea* in the lands he visited, and M. Turquet notes[1] the colour given to the landscapes of Gerlache Strait and Graham Land by *Usnea* and *Lecidea*. M. Gain

[1] *Le Français au Pôle Sud*, J. Charcot, Paris, 1906, v., "La Vie végétale," pp. 434–438.

of the *Pourquoi Pas?* speaks[1] of the almost continuous carpets of *Usnea* at Deception Island.

Two other species, *Rhizocarpon geographicum*, D.C., and *Lecidea fusco-atra*, Th. Fr., are less abundant, and owing to their more sombre colour and less striking appearance do not, as a rule, lend any very characteristic feature to the landscape. The number of Antarctic lichens so far known is 88, but the reports on several recent collections have yet to be published. Future exploration will certainly add greatly to this number. Eleven species were found by the *Scotia* at the South Orkneys, and with regard to these Dr O. V. Darbishire reports[2] that all except one were previously recorded from some part of the Arctic regions, and that, taking into account all known collections, the proportion of Arctic species is as high as 73 to 75 per cent. Of the *Discovery* collections 76 per cent. were also Arctic in distribution. The lichens of Gerlache Strait as collected by the *Belgica* numbered 55, including a new species of *Placodium* (*P. regale*, Wainio), which was also found by me at the South Orkneys and independently described as *P. fruticulosum*, Darbish.: Wainio's name, however, has priority. Of these 55 species 38·2 per cent. were known from Arctic regions, and as many as 52·7 per cent. were new. All the 3 species recorded from Wilhelm Land are of wide distribution. Since these statistics include in each case many cosmopolitan or very widely spread species, which are common among lichens, it would be unwise to base on them arguments concerning the origin of the Antarctic flora.

The multicellular algæ of Antarctic seas are quite abundant as regards individuals, if perhaps the species are not very numerous. Fifteen species are recorded by Mr and Mrs Gepp from my South Orkney collections, and Mr Holmes records 9 other species in a small collection made by the expedition in the same place. Of the species determined by Mr and Mrs Gepp, 5 are new. I am confident that careful exploration of the coasts of these islands at seasons when they are free from ice would reveal many more species. As was only to be expected, the littoral region, *i.e.* the area between high and low water, proved poor both in individuals and species; calcareous species are the most abundant in that region. The wearing and tearing action of the ice is not compatible with much algal growth in these shallow waters, and this no doubt accounts for the absence of the southern kelp (*Macrocystis pyrifera*) from the true Antarctic regions. The majority of the algæ occur at greater depths. The daily haul of the dredge which we took in Scotia Bay scarcely ever failed to bring up specimens of algæ. The two red algæ (*Plocamium coccineum*, Lyngb., and *Acanthococcus spinuliger*, Hook. and Harv.) were extraordinarily abundant in 10 fathoms, and the brown alga (*Desmarestia Rossii*, Hook. and Harv.) was frequent in shallower water. Calcareous algæ were obtained almost daily in 9 to 10 fathoms. In places these algæ cover the rocks in a few feet of water with so continuous an incrustation that at first sight one is deceived into the belief that it is an ice formation. Probably the most interesting find

[1] *Rapports préliminaires sur les travaux exécutés dans l'antarctique*, Académie des Sciences, Paris, 1910, p. 99.

[2] See this volume, pp. 24–29, and "The Botany of the South Orkneys: Lichens," O. V. Darbishire (*loc. cit.*).

among the *Scotia* algæ was the new species *Phyllogigas simulans*. This was first described (*loc. cit.*) by Mr and Mrs Gepp from material I collected at the South Orkneys. Since then it has also been found at Graham Land and South Georgia by Dr Skottsberg, and another species (*P. grandifolia*) has been recorded by the *Discovery* from Victoria Land. It is a genus whose species have some similarities in habit to that of the "kelp," although it is anything but abundant.

Our knowledge of Antarctic multicellular algæ is practically confined to the Graham and Victoria Land regions; and though most of the collections are now published, it would be rash to draw any deductions of a distributional nature; for while the Graham Land region has been the more carefully explored of the two, neither can be said to be known thoroughly as regards its algæ. Some 40 species are at present known from Antarctic seas, of which about 75 per cent. occur at Graham Land, and about 40 per cent. at Victoria Land. Dr Skottsberg has discussed in various papers (see Bibliography) the distribution of these algæ as far as is possible, and he finds that no facts in this realm of botany support the idea of bipolarity.

Only one species of freshwater alga (other than unicellular and colonial algæ) is so far known, viz. the cosmopolitan *Prasiola crispa*, Ag., which is recorded from both Graham Land and the South Orkneys.[1] In the latter place it was to be found in summer and autumn in several small gulleys where a quantity of melting snow above assured a continual supply of moisture.

Unicellular algæ naturally form the vast preponderance of the botanical treasures of the Antarctic regions. When once the regions of ice are approached, between 50° S. and 60° S., the plankton entirely changes its character; crustaceans, and in fact all animals, then become rare, and give place to increasing numbers of diatoms until, in the midst of the ice, the diatoms occur in such prodigious quantities that five minutes' haul of the tow-net (No. 20 miller's gauze) produces as much as a pint of gelatinous residue almost wholly diatomaceous. The fact that such a net, used about thrice daily on the average, ceases to be serviceable after about a week or ten days' use, owing to the clogging of the apertures in the silk, will give an idea to anyone accustomed to plankton work of the wealth of diatomaceous life in these seas. The species are not very varied, but a large proportion of them bear spines and long arms, while simple forms are comparatively rare. Peridineans occur, but only rarely. The phytoplankton on the whole seems to favour deep water, for in the shallow water about the South Orkneys it was much scarcer. In winter the greater part is apparently frozen into the ice, for I failed to get any appreciable quantities from the water on the occasions when I bored the floe with this object in view. The first-formed pancake ice is always yellow, and the lower layers of the floe as revealed in the spring upheaval are uniformly discoloured by a layer of diatomaceous ice.

In no part of the Antarctic seas visited by the *Scotia* did I observe the open water

[1] Some authorities recognise *Prasiola antarctica*, Kutz, in addition to *P. crispa*, in Antarctic lands. See "Freshwater Algæ," W. and G. S. West, *Brit. Antarct. Exped.* (*1907–09*), 1911, vol. i., and F. E. Fritsch, p. 128 of this volume.

discoloured by diatoms, and I am not aware that other recent expeditions have recorded this occurrence; but Dr W. S. Bruce, in the cruise of the *Balæna* in 1892–93 between 62° and 63° S., off Louis Philippe Land, frequently remarked that the sea was olive-green or olive-brown from this cause, and that the most usual species in these discoloured parts was *Corethron criophilum.* This phenomenon is of much commoner occurrence in Arctic seas.[1] Plankton collections well within Antarctic seas and over a wide area are largely confined to the collections of the *Scotia*, which fortunately was able to traverse some 10,000 miles of unexplored south polar waters. The other recent expeditions, *Discovery*, *Antarctic*, *Gauss*, *Français*, and *Nimrod*, did comparatively little marine exploration within truly polar waters. The *Belgica's* results in this department should, however, be of great interest, and will be supplemented by those of the *Pourquoi Pas?*, while the *Valdivia's* collections, though in more or less extra-polar waters, have important relation to Antarctic plankton. A detailed report and discussion of the *Scotia's* plankton is in process of completion.

While freshwater algæ appear to be comparatively abundant, they are not nearly so plentiful as in north polar regions. In the collections which I made at the South Orkneys, Dr Fritsch has found 68 species (of which 5 are new): most are unicellular and colonial.[2] With the exception of the *Belgica*, the *Southern Cross*, the *Discovery*, and the *Nimrod*, other expeditions have not yet published their results in this branch of botany. A number of forms, however, have been recorded from Kerguelen and South Georgia.

Among the South Orkney collections very few reproductive stages were found even in material collected about midsummer, and Dr Fritsch believes that many species only reproduce during very limited periods under specially favourable conditions. The rarity of diatoms and infrequence of desmids in this freshwater flora are noteworthy None of the new forms of diatoms in either the *Discovery* or *Nimrod* collections occur at the South Orkneys.

Red and yellow snow occur at the South Orkneys, though neither is abundant. Red snow has been recorded from Arctic regions, as well as other parts of Antarctic regions, including Graham Land and Victoria Land: it is also recorded from extra-polar regions. Yellow snow is much rarer, and I am not aware that other Antarctic expeditions came across it. Dr Fritsch has reported in considerable detail on these coloured snows (*loc. cit.*), and he finds that yellow snow is due to an association of 18 species of algæ and 2 of fungi; most of the algæ are green forms, but few diatoms occur. The whole of this flora has a plankton character, and Dr Fritsch suggests that this and other snow floras may have arisen by wind carriage of plankton forms to the snow surface. Most of the constituent members of this flora have a quantity of fat in their cell contents, in which yellow pigment occurs. This fact seems to be an adaptation to the severity of the habitat.

[1] "On the Nature of the Discoloration of the Arctic Seas," Robert Brown, *Trans. Bot. Soc. Edin.*, ix. p. 244.

[2] See this volume, pp. 95–134, and "Freshwater Algæ collected in the South Orkneys," *Journ. Linn. Soc. Lond* xl., 1912, pp. 293–338.

The red snow of the South Orkneys is also due to an algal association, but one that is considerably poorer both in species and individuals than that causing yellow snow. Most of the algal forms seem to contain fat in many of their cells. While the red colour of these South Orkney samples appears to be due, as in the case of Arctic occurrences, to *Chlamydomonas nivalis* (*Sphaerella nivalis*), it is difficult to say definitely in preserved material. Mr James Murray believes that the red snow of Victoria Land is sometimes due to red rotifers, whose abundance in the Antarctic he was the first to demonstrate. Red rotifers were found in Agassiz' red snow from the Alps, but have not been recorded from the South Orkneys. The red colour Mr Murray ascribes to the nature of the food. Elsewhere in this paper (p. 6) I have commented on the significance of Dr Fritsch's discovery of pollen grains of *Podocarpus* in the red snow, as proof of the occurrence of wind transportation from adjacent lands to Antarctica.

Such, in outline, is the present state of our knowledge of the botany of Antarctic regions, and it will be seen that by far the greater part is due to the labours of the expeditions of the last ten years. Of course such a survey as this must necessarily be incomplete, as several important papers on recent collections still remain to be published, and even when this is done our botanical knowledge of the Antarctic will have many gaps: further collections are much to be desired, especially from the Pacific and Indian sides, whence practically nothing is known, beyond of course the collections of the *Belgica*, *Français*, and *Pourquoi Pas?* on the west of Graham Land, and the various collections from Victoria Land. Among the Antarctic lands from which no plants are known are Coats Land, Enderby and Kemp Lands, Termination Land (if this long-lost land is identical with Drygalski's reported "high land"), Wilkes Land, Edward Land, Charcot Land, and Alexander Land—not to omit New South Greenland if that great peninsula really exists in the Weddell Sea—though it is quite to be expected that their flora is very scanty since they are more or less covered with ice and little bare rock appears. The explorations of the *Aurora* in Wilkes Land, the *Deutschland* in Coats Land, and the *Fram* in Edward Land should add to our knowledge of Antarctic botany.

While our knowledge of Antarctic flora is certainly incomplete, all the known facts point to a Fuegian origin. Not only does an analysis of the distribution of the constituent elements indicate this, but the relative greater abundance of species in Graham Land and vicinity than in Victoria Land, as well as the absence of New Zealand forms, shows that the flora of the Antarctic is due to an emigration of species from Fuegian lands. I have discussed above (pp. 6 and 7) the ways in which seeds might cross Drake Strait. Winds and birds must have done the work of giving Antarctica its present flora, *via* Graham Land from Fuegia, and thence it must have spread westward *via* the coasts to Victoria Land, but naturally only a small proportion of the species were carried so far. However, it is quite possible that by the same agencies a certain number of mosses and lichens may have reached Wilkes Land and Wilhelm Land from Kerguelen and Heard Island, while South Georgia and the South Sandwich group may have contributed to Coats Land and the coast eastward towards Enderby Land. The floras of all these sub-antarctic islands from the Falklands eastward to Kerguelen have been shown to be related to one another, and to have strong Fuegian affinities; and Dr Cockayne has pointed out the relationship between the flora of Kerguelen and that of Macquarie Island.

In a later part of this paper (pp. 17–20) is a fuller discussion of these islands and their floras; but this close relationship with Fuegia that they all exhibit, means that emigration of a species from any of these islands to Antarctica amounts to emigration from Fuegia by a somewhat circuitous route. No other lands are near enough to Antarctica to have affected its flora.

In relation to the flora of South Georgia, Dr Skottsberg has discussed at some length the probability of wind and bird carriage of various species: reference should be made to that paper.[1] Taking into account our incomplete knowledge of the Antarctic flora, the total number of species which occur in Antarctica may seem large when all must have been brought by such chance agencies as wind and birds; yet I believe that the existing species in Antarctic regions represent a small proportion of those that have reached there. The probability of seeds and spores reaching a location suitable for growth is small, and even then only specially favoured species could survive the adverse conditions of life with which they have to contend. The high proportion of endemic species among the mosses in particular is, of course, the outcome of this most specialised environment.

One element of the Antarctic flora may appear to present a difficulty in the way of the acceptance of this theory—that is, the northern element. Dr Cardot has found a large proportion of these forms among the mosses of both Antarctic and sub-antarctic regions. But their presence can be satisfactorily explained, and that without recourse to the now discredited theory of bipolarity. Dr Cardot suggests[2] that the spores and soredia of these mosses and lichens may be transported on the feet and plumage of those birds which we now know wander between high northern and high southern latitudes. Wilson's petrel (*Oceanites oceanicus*), which breeds in the Arctic regions, was found by us during the northern winter off Coats Land; the northern tern (*Sterna macrura*) was proved by the naturalists of the *Scotia* to wander almost from pole to pole; and other species of birds might be cited that range between Alaska and Fuegia. While there may be some degree of probability in Dr Cardot's theory, I do not feel it gives an adequate explanation of the facts, and I think that a more satisfactory and simpler explanation is to be found in the idea that the species of mosses and lichens in question are either cosmopolitan, but have not been discovered in low latitudes, or that they are species which have spread from northern to southern regions (or *vice versa*) by means of mountain ranges or bird and wind transport, but which

[1] "Die Gefasspflanzen Sudgeorgiens," Carl Skottsberg, *Wissen. Erg. Schwed. Südpolar-Exp.*, iv. 3.

[2] "Note sur la Flore de l'Antarctide," Jules Cardot, *Comptes rendus de l'Assoc. Française pour l'avancement des Sciences*, 1907, pp. 452–460.

have failed to prosper in low latitudes either by inability to become adapted to the physical conditions, or by stress of competition.

Although the foregoing explanation seems to solve the problem of the origin of the Antarctic flora, it may be as well to examine other solutions which have been put forward.

It has been suggested that the present flora represents the relics of a richer flora from pre-glacial days, which doubtless reached Antarctica by land connections with America and Australia. The existence of these land connections has certainly been established beyond doubt by the work of the *Belgica*, *Scotia*, *Antarctic*, *Nimrod*, and other expeditions; yet, for reasons that I will explain, it is doubtful if they can help to answer the question of the origin of the flora.

In every part of Antarctic regions explored by recent expeditions proofs of a former great extension of glaciation have been found, and this at a date posterior to those late Secondary and early Tertiary land connections. M. Arctowski of the *Belgica* showed that Gerlache Strait was once filled by an immense glacier. Dr Gunnar Andersson speaks of an island (Moose Island) in the same strait over 600 feet, rising from over 600 fathoms depths of water, which shows indisputable signs of ice-action on the top. At Borchgrevinck Nunatak, in 66° S. in Graham Land, it was found by Dr Otto Nordenskjöld that the ice-sheet formerly was about 1000 feet above its present level.[1] According to the German Antarctic Expedition the ice-sheet of Wilhelm Land, which is now some 900 feet thick, was at one time 1300 feet.

The South Orkneys show similar traces of this greater glaciation in the past, and Captain Scott noted it in Victoria Land. Messrs David and Priestley of the *Nimrod* believe that McMurdo Sound was once filled with a branch of the Ross Barrier, whose general surface was then 1000 feet above sea-level, in contrast to 150 feet to-day. And many other instances could be cited. Under these conditions of glaciation little if any land can have been exposed, unless it was a mere mountain top or cliff side.[2]

Moreover, there are not wanting signs that after this period of maximum glaciation the land rose. Dr Gunnar Andersson found signs of emergence of the land at several localities in Graham Land visited by the Swedish Antarctic Expedition. Messrs David and Priestley suggest emergence of the land as an explanation of the raised beaches of Victoria Land.[3] From all the available evidence they conclude that the land has emerged possibly as much as 130 feet.

Now, if this was the case, and there was depression of the land during the extreme glacial period—perhaps due to the enormous superincumbent weight—the great majority of the low-lying places near the sea, including many small islands, which at present harbour the flora of Antarctica, must have been below water, while all those more elevated places of to-day which now bear vegetation were enveloped in ice. The

[1] "On the Geology of Graham Land," J. G. Andersson, *Bull. Geol. Instit.*, Upsala, vii., 1906, pp. 19–71.

[2] It should, however, be noted that Dr O. Nordenskjold holds a contrary opinion, believing that the maximum glaciation did not cover all the land with ice. *Geog. Journ.*, Sept. 1911. While recognising the high authority of the writer, I must confess to be unable to agree with him.

[3] *The Heart of the Antarctic*, E. H. Shackleton, London, 1909, vol. ii. p. 271.

present loci for the scanty flora of Antarctica can only have become such when glaciation had for some time diminished.

It is difficult to believe that any species, unless possibly a lichen or two, can be a survivor of an older Antarctic flora.

At the period of severest glaciation the sub-antarctic islands were heavily glaciated —of that we have proof in many cases—but probably not to such an extent as to exterminate any pre-existing flora, only greatly to diminish it, though there are indications that in South Georgia and Macquarie Island the flora was wiped out.

Turning now from the true Antarctic regions to the austral or sub-antarctic regions, consisting mainly of the many islands that gird the Antarctic seas, it must be said that it is here that the most fruitful botanical collections of future expeditions will probably be made. This ring of circum-polar islands includes the following:—Fuegia, the Falklands, South Georgia, South Sandwich group, Tristan da Cunha with Gough Island, Bouvet Island, Prince Edward and Marion Islands, the Crozets including Possession Island, Kerguelen, Macdonald and Heard Islands, St Paul and Amsterdam, Campbell and Auckland Islands, Macquarie Island, and Dougherty [1] or Keates Island, with a few others whose existence is somewhat hypothetical. In passing it may be as well to note that I have included all these islands in the general category of sub-antarctic merely for the sake of convenience in this place, and do not intend to imply that on botanical grounds they can be grouped in the same domain: for a discussion of the classification of these islands reference should be made to Dr Skottsberg's paper (*loc. cit.*). Of these islands Fuegia and adjoining Patagonia, as well as the Falklands, have been well studied by various expeditions, including the recent most fruitful one led by Dr Skottsberg; South Georgia has been recently re-explored by the Swedish Antarctic Expedition; Tristan da Cunha has hardly been exhausted despite the visit of the *Challenger*; Gough Island, on which I had the privilege of being the first botanist to land, would well repay a visit; Prince Edward and Marion Islands, the Crozets, Kerguelen, Macdonald and Heard Islands, are far from well known, except perhaps Kerguelen; St Paul and Amsterdam Islands are better known, and the New Zealand group, including Campbell, Auckland, and Macquarie Islands, and the Antipodes, have lately received more attention. But all would be worth the attention of a careful explorer, especially as regards the lower forms of plant life. Bouvet and Dougherty Islands are altogether unknown from a botanical or almost any other standpoint. Bouvet Island, according to the *Valdivia's* reports, is entirely covered with ice, and is devoid of vegetation: moreover it offers no landing-place. On the other hand, previous voyagers have given the island a slightly better reputation, Bouvet (1739) and Lindsay (1808) both reporting trees and shrubs (? tussock grass), and Morrell (1823) speaking of small spots of vegetation. Whatever may be the case it well

[1] The *Discovery* reported that this island does not exist in its formerly assigned position, and Captain J. K. Davis of the *Nimrod* cast grave doubts on the existence of Emerald Island and the Royal Company Islands as well as Dougherty Island.

merits a visit, and in view of its probable accessibility at all times of the year, even in an iron vessel, it is to be hoped it will not be long before we have some definite knowledge of the natural history of the island and its surrounding waters. Gough Island, I can assure any intending botanical explorer, will more than repay a visit, and it is not difficult of access, though landing may be a little troublesome.[1] Many important botanical discoveries could be relied on.

The six islands lying in the extreme South Atlantic, which were discovered and named by Cook in 1775 the South Sandwich group, are probably the most neglected spot in all sub-antarctic regions, and no expedition since that of Bellingshausen in 1820, with the ships *Wostok* and *Mirny*, has visited them, though several sealers and whalers report that they are quite accessible and contain some good harbours, especially one on Bristol Island. Forster, the German naturalist who accompanied Cook, says no vegetation was to be seen, though Cook himself mentions that he observed vegetation to the north end of Saunders Island. Morrell in his somewhat doubtful voyage of 1823, speaking of the islands, says they are "entirely barren." The *Scotia*, on her first Antarctic voyage in 1903, passed within twenty miles of Southern Thule, the southernmost island of the group, but thick and boisterous weather prevented a nearer approach and time was too precious for the southern cruise to admit of delay: on our return from Coats Land in 1904 an attempt was made to reach the group, but continual adverse gales and a shortage of coal caused the project to be abandoned. Nothing therefore is really known of this group, and a large field is open for some future explorer.[2] It is to be hoped that the *Deutschland* will succeed in her contemplated exploration of this group. Probably it will be found that all the islands of the group are not barren of vegetation, while their extreme interest from a botanical point of view lies in their position intermediate between Antarctic and sub-antarctic zones, the southernmost islands approximating to the Antarctic conditions, though doubtless not quite so rigorous, and the northernmost islands no doubt having a climate somewhat similar to that of South Georgia, or perhaps a little more severe. In this chain of islands extending through three degrees of latitude, one should be able to study the gradual transition from sub-antarctic to Antarctic flora in a way which no other part of the south polar regions permits. There is every reason, therefore, to expect that the vegetation of the northern islands will approximate to that of South Georgia, and that of the southern islands, at least Thule and Bristol Islands, will show some similarity to the true Antarctic facies. The floral statistics should also prove of great interest, and may throw some light on the vexed question of the origin of southern floras and former land connections. The flora, especially of Traversey and Candlemas Islands, will probably show a distinct South Georgian and consequently South American relationship, but

[1] "Diego Alvarez, or Gough Island," R. N. Rudmose Brown, *Scot. Geog. Mag.*, xxi. p. 430 *et seq.*

[2] An account of some zoological collections made at the Sandwich group by Captain Larsen and Dr F. Lahille of Buenos Aires has recently appeared (*Ann. de Mus. Nac. de Hist. Nat.*, ser. iii. vol. xiv.), but at the time of going to press I have not heard whether this expedition had any botanical results. The *Deutschland* in November 1911 was said to have visited this group of islands.

the point of extreme interest to be looked for is whether it will show near relationships to the flora of the Crozets on the one hand, or to that of the Tristan da Cunha group on the other, and it will be interesting to find out how far this Sandwich group flora has evolved, and whether any new and distinct species have originated. The flora of South Georgia has practically no relationship to that of Tristan da Cunha or Gough Island, but a certain affinity with that of the Crozets and other islands to the east, and with the Antarctic regions properly speaking: of its 93 species of mosses, 16 are also found in the Antarctic. Its Magellan affinities are more pronounced: indeed, it seems probable, as Dr Skottsberg maintains (*loc. cit.*), that the flora is derived entirely from Fuegia and the Falklands; no species, he asserts, shows any other origin. Yet considering its nearness to Fuegia, and the prevailing westerly winds, it is a matter for wonder that more of the Fuegian species are not found there, and that the proportion of endemic species should be so high in respect of mosses, viz. over 45 per cent., according to Dr Cardot's determinations. Among its 15 species of phanerogams are none which are endemic, a fact not a little remarkable considering how, in similarly isolated islands, such as Tristan da Cunha and Gough Island, the endemic species and varieties form a conspicuous element of the flora, while Kerguelen and other islands to the east are also not wanting in this respect. Possibly the relative accessibility of South Georgia to the Magellan Lands accounts for its want of peculiar species; but if this is so, the number of endemic mosses does not become easier of comprehension, nor the paucity of phanerogams, since there are other Fuegian and Falkland species quite suitable for South Georgian conditions and adapted for wind and bird transpersion.

The affinities of the flora of the New Zealand group of sub-antarctic islands with that of Fuegia, which Dr L. Cockayne and others have demonstrated, and to which reference was made above, is another striking fact. Recent exploration undertaken by the New Zealand Government has added much to our former knowledge of these islands.[1] The whole flora of the Snares, the Aucklands, Campbell Island, the Antipodes, and Macquarie Island, contains, as far as our present knowledge goes, 194 species of flowering plants, among which there is a New Zealand element of 133 species, an endemic one of 53 species, and a Fuegian-South-Georgian-Kerguelen element of 8 species unknown in New Zealand. The New Zealand species are probably of comparatively recent introduction, and reached the islands since they were separated from New Zealand. The endemic element shows in some cases New Zealand affinities, in others none at all. The first part was no doubt derived from New Zealand in the long past; the second part represents the relics of some older pre-glacial flora. The Fuegian element has been introduced by wind and bird transport: with so small a percentage of species this is quite likely. On the other hand, out of the 88 genera of phanerogams in these islands, no less than 56 have representatives in Fuegia. This obviously points to some most intimate link between the floras of these islands and that of Fuegia in the

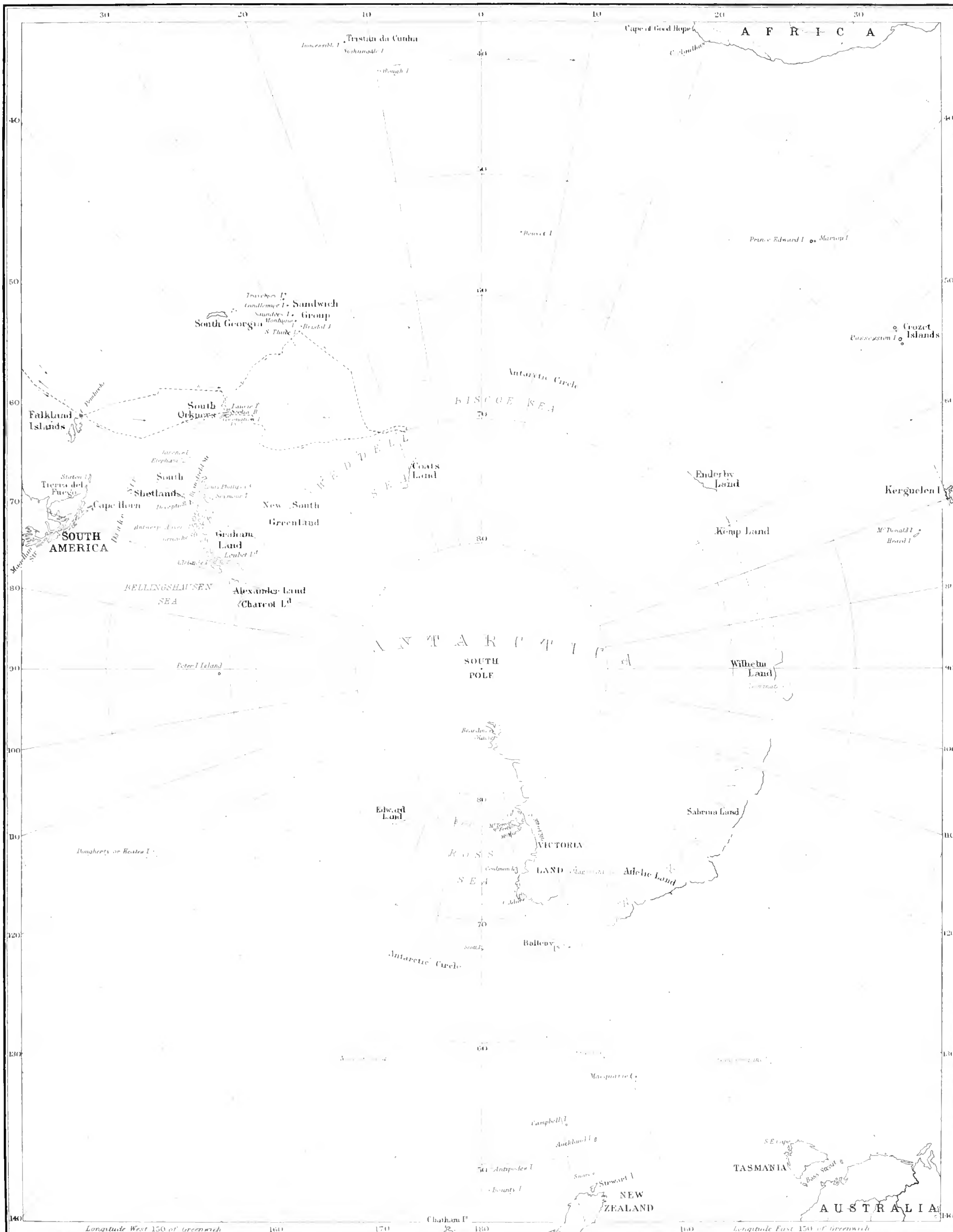
[1] *The Sub-antarctic Islands of New Zealand*, C. Chilton, L. Cockayne, T. F. Cheeseman, and others, Christchurch, N.Z., 1909.

past. Such a link could only have been made by land connections, and it was probably at the time of the last stages of the former wide northward extension of Antarctica that this deep-seated affinity between these floras must be dated. To name an epoch for this would be rash: possibly these land bridges were available as late as Eocene times. After they were no longer in existence, the floras of the various islands developed each along its own lines, and the endemic species were evolved. The only later additions were by wind and bird transport from Fuegia and from New Zealand.

A full discussion of the relationships of the floras of these southern islands in their possible bearing on the former distribution of land has great importance, but is outside the purpose of the present paper. Enough has been said to indicate the nature of the botanical problems awaiting solution in Antarctic and sub-antarctic lands, and while future expeditions will naturally choose their routes largely for oceanographical and geographical reasons, there always will be in any land touched at, or for that matter in any sea, sufficient material of botanical interest to be found.

The pole-circling islands and the coasts of Antarctica are more likely to be well explored as the importance of the study of the vast southern oceans begins to attract the attention it deserves, and when the day of record-breaking pole-hunts is over, as it soon must be now that Roald Amundsen has won the race. The present Australasian expedition with no pole-reaching ambitions is a welcome sign of the trend of exploration.

CHART TO SHOW THE DISTRIBUTION OF LAND IN ANTARCTIC & SUB-ANTARCTIC REGIONS



The Edinburgh Geographical Institute

II.—THE BOTANY OF THE SOUTH ORKNEYS.

II.—THE BOTANY OF THE SOUTH ORKNEYS.[1]

By R. N. Rudmose Brown, D.Sc., and O. V. Darbishire, B.A., Ph.D.

(*With a Plate.*)

I. INTRODUCTORY.

By R. N. Rudmose Brown, D.Sc.

The small group of islands known as the South Orkneys is situated between 60° and 61° S. and 44° and 47° W., about 600 miles S.E. by E. of the Falkland Islands, and about 200 miles east of the nearest islands of the South Shetlands. They were discovered in 1821 by Powell in the sloop *Dove*, and were subsequently visited by Weddell in the brigs *Jane* and *Beaufoy* in 1823, by Dumont d'Urville in the *Astrolabe* in 1838, and by Larsen in the whaler *Jason* in 1893.

In February 1903 the Scottish National Antarctic Expedition in the ship *Scotia* made a landing on Saddle Island—the most northerly island of the group—on their way to the south. In the end of March the same year the *Scotia* returned to the islands to winter, and spent eight months at Laurie Island. The group consists of two large islands—Coronation and Laurie Island, and many smaller ones. Coronation Island, or Mainland, is the westerly, and Laurie Island the easterly. It was on the latter island, in the south of which is Scotia Bay, that the greater part of the botanical collections were made. These two islands are separated from one another by two small islands and Washington and Leathwaite Straits. Of the outlying islands the most important is Saddle Island, lying about eight miles north of Laurie Island. Ailsa Craig, mentioned several times in this paper, is a large rocky crag standing at the mouth of Scotia Bay. Deep bays run into the land from north and south, separated by narrow rocky peninsulas or steep and lofty mountain ranges. All the valleys are choked with glaciers, despite the relatively small gathering-ground on the heights above, and what little exposed rock is visible is precipitous in the extreme. It is only here and there that a few acres of more or less level ground are to be found on the lower slopes or at sea-level. Although in a comparatively low southern latitude, the South Orkneys are sometimes ice-bound for some six to eight months of the year. In other years they may enjoy more oceanic conditions and escape this extreme rigour. In midwinter practically everything, even to the faces of precipitous cliffs, is covered with snow, and

[1] Reprinted with alterations and corrections from *Trans. and Proc. Bot. Soc. Edin.*, xxiii. i., 1905, pp. 105–110.

not before October or November does much of the snow disappear. In these months many patches of moss-covered ground come to light, and in some of them, by successive years' growth, 6 to 10 inches of soil have been formed. Except this vegetable mould, there is little soil anywhere. The rocks—various kinds of greywacke—are mostly covered with lichens, particularly *Usnea* and *Placodium*, and Weddell,[1] to whom we are indebted for the first account of the islands, mentions that at Cape Dundas, where he landed, "there was a patch of short 'grass.'" During the winter and spring that the Scottish National Antarctic Expedition spent at the South Orkneys, I made a very careful search for this grass both at Cape Dundas and elsewhere, but failed to find any signs of it. It is possible that this grass may have been casually introduced, and succumbed after a few seasons to the severity of the climate, or been unable to grow on account of the numbers of penguins that frequent the place, yet I am inclined to think Weddell mistook a lichen (*Usnea melaxantha*), growing luxuriantly at Cape Dundas, for a grass. This was also the impression of Dumont d'Urville, who visited the island in 1838.[2] Cape Dundas, it must be remembered, is the easternmost point of the islands, and therefore the least likely spot for wind-carried seeds to be deposited in that region of the westerly winds; and the coast there is unprotected and the anchorage bad, which make it improbable that whalers who could have been responsible for the introduction of the plant would have landed there, unless, like Weddell, they had a scientific end in view. However, it is worth noting that the South Shetlands and Graham Land, which are very similar in physical conditions to the South Orkneys, support *Deschampsia antarctica*, and Graham Land *Colobanthus crassifolius*. Owing to the fact that the South Orkneys lie within the region normally ice-bound in winter, the temperature is comparatively low, ranging from a mean of 9·7° F. in midwinter (July) to 31·5° F. in midsummer (January). The extreme range is from −40° F. to 47·8° F., but an approach to either of these extremes, particularly the latter, is rare. The mean of the year is 23·36° F.[3] Snowfall is great, sunshine very deficient, and strong gales frequent.

The mosses of the South Orkneys are considered in Dr Cardot's paper, on pp. 55–57 of this volume.

II. THE LICHENS OF THE SOUTH ORKNEYS.

By Otto V. Darbishire, B.A., Ph.D.

The lichens of the Arctic regions are fairly well known, and for this state of things there are three reasons. The limits of the Arctic regions are well defined; furthermore, a very large amount of material has at various times been brought back to Europe; and, lastly, this material has been worked through critically and as a whole by various lichenologists.

[1] *A Voyage toward the South Pole in the years 1822–24*, James Weddell, London, 1825, p. 24.

[2] *Voyage du Pôle Sud*, Dumont d'Urville, Paris, 1841–45, vol. ii. p. 131.

[3] Subsequent data will slightly alter these values, but probably not more than a fraction of a degree. The values here given are the means for five years.

With regard to the Antarctic lichens, on the other hand, we have three difficulties to contend with. The limits of the Antarctic regions do not admit of easy definition. We have, secondly, no very extensive and exhaustive collections from certain limited areas, but rather a sample taken here and a sample taken there, in localities to which often flying visits only have been paid by expeditions. This becomes the case more and more the farther south we go. Of course the scattered nature of the land, which may be included in the term Antarctic, is largely responsible for this being the case. Lastly, we are still in want of a critical examination of all the herbarium material that has so far been collected, and all that there is to be found in the literature. There must be a sufficiently great quantity of material in European and American herbaria, and in the literature of the subject, to make such a critical examination a fairly hopeful undertaking. But a compilation of the printed records must be accompanied by a critical examination of the corresponding herbarium specimens.

Till this herculean task has been successfully accomplished we must confine our energies to getting hold of every possible morsel of lichen material from the Antarctic regions and carefully recording name and locality. From this point of view the lichens brought back by the Scottish National Antarctic Expedition, and collected by Mr R. N. Rudmose Brown, are very interesting and valuable. Eleven species were collected at the South Orkneys.

I will now enumerate the species, adding any observations that may appear necessary, and then make some more general remarks on the distribution of Antarctic lichens.

LECIDEA FUSCO-ATRA (*L.*), *Th. Fr.*—Occurs in the Arctic regions. South Orkneys.

RHIZOCARPON GEOGRAPHICUM (*L.*), *D.C.*—Found on rocks in Scotia Bay, South Orkneys. It is a cosmopolitan species, being frequently met with in the Arctic regions, and it may also be described as being a typical Alpine plant.

GYROPHORA VELLEA (*L.*), *Ach.* (or VELLEREA (*L.*), *Ach.*, according to Arnold) was collected on rocks on the south-west shore of Scotia Bay rising to a height of 1000 feet. It was also collected on Saddle Island at a height of 300 feet. The specimens were all well developed, one measuring as much as 11 by 20 cm. The latter was found growing in close association with *Usnea melaxantha*, Ach., some plants of which were actually firmly attached to the surface of the *Gyrophora* plant. *Gyrophora vellea* is recorded from America and Europe, being an Arctic and Alpine plant.

CLADONIA FIMBRIATA (*L.*), *Fr.*—This species, though otherwise cosmopolitan in distribution, does not occur in the extreme Arctic regions, and its discovery in the South Orkneys, where it was found between moss in Scotia Bay, is of great interest.

CLADONIA DEFORMIS (*Ach.*), *Hffm.*—A few specimens of a *Cladonia* brought from Scotia Bay, South Orkneys, seem to belong to this species. It is again cosmopolitan, being also a typical Arctic and Alpine plant.

Usnea melaxantha, *Ach.*, is common both in the Arctic and Antarctic regions of America and Europe, and also in New Zealand and the Andes. A number of species appear to be nearly related to this plant, but they are not all quite clearly defined. I am referring to *U. Taylori* (Hook.); *U. Hieronymi*, Krphbr.; *U. trachycarpa*, Müll.-Arg.; and even *U. sulphurea*, König, which is probably only a synonym of *U. melaxantha*, Ach. Some of the specimens were found growing on and firmly attached to *Gyrophora vellea.*

Bryopogon jubatum, *Link.*—Cosmopolitan, Arctic, and typically Alpine. Small plants were found in between specimens of *Usnea melaxantha* from the South Orkneys.

Rinodina turfacea (*Wahlenb.*), *Fr.*—Europe, Asia, and America, Alpine and Arctic. The material collected from a rock on the South Orkneys must, I think, be included in this species. It has a remarkably well-developed, thick thallus, but this may be due to its unusual habitat on rocks.

Placodium elegans (*Ach.*), *Nyl.*—Cosmopolitan, Arctic, and typically Alpine. Good fertile specimens were found on rocks on the south-west shore of Scotia Bay, South Orkneys.

Placodium regale, *Wainio* (= Placodium fruticulosum, Darbish., *Trans. and Proc. Bot. Soc. Edin.*, xxiii. 1. (1905)[1]).—Thallus fruticulosus, basi substrato affixus. Protothallus gonidiis destitutus, chondroideus, margo effusus et hyphis instructus solitariis vel conglutinatis. Podetia fruticulosa, ad marginem thalli prostrata et leviter compressa, inferne albida, nondum substrato affixa nisi protothallo; ad centrum thalli erecta, 1–2 cm. alta, dichotome sed irregulariter divisa, 1–1·5 mm. crassa, ad apices bene divisa; apices juxtapositi thallum crustaceum simulantes; aurantiaca aut flavescentia, KHO purpurascentia; stratum corticale hyphis instructum transversalibus, cuticulo valde distincto obtectum 6–8 μ lato; stratum medullare dense strupeum. Gonidia protococcoidea. Apothecia lecanorina, 1–4 mm. lata, emergentia, sed adpressa, lateralia; amphithecium distinctum, gonidiis instructum; parathecium decoloratum; epithecium flavescens aut aurantiacum, KHO purpurascens; hypothecium decoloratum, strato gonidiali inferne instructum; thecium 90–100 μ crassum; paraphyses simplices, apice cellulis brevibus terminantes; axi cylindrici, elevati 10 μ lati; sporæ octonæ hyalinæ bicellulares orculiformes, 5–6 × 11·5 μ magnæ. Spermogonia et soralia non visa. Habitat ad saxa, S. Orkneys.

Placodium regale was found growing on rocks around Scotia Bay, South Orkneys. It is apparently very common from the shore right up to the summit, evidently representing an important constituent of the lichen vegetation. The podetia are fruticulose and erect, branching frequently and in an irregular way. The tips of the branches, however, are pretty much of the same height, and being very closely applied to one

[1] This species was described independently by M. Wainio and Dr Darbishire from the *Belgica* and *Scotia* collections.—R. N. R. B.

another, this lichen appears to be crustaceous. The exposed parts of the plant are light yellow or orange coloured, but those more hidden are paler, and in part even white. The lowest portions of the podetia can obtain a thickness of about 1·5 mm., the tips being as much as 1 mm. across. The podetia measure up to 2 cm. in height, and are generally cylindrical in section near the margin. Near the margin of the whole thallus they generally assume a more typical Placodium structure. The marginal podetia show a dorsi-ventral arrangement, the short assimilators springing from the upper side only. But even here, near the margin, the dorsiventral and free podetia can be distinguished perfectly from the protothallus, which is firmly attached to the rocky substratum.

The protothallus consists of fine strands of fungal hyphæ, which, white in colour, radiate out in an irregular manner from the base of the podetia. At this latter point the protothallus is often very thick.

The gonidia are fairly evenly distributed in the podetia, where these are exposed to light, but the gonidia are massed together at those points where a new branch or an assimilator is about to sprout.

The general structure of the apothecium is that typical of Placodium species. It is up to 4 mm. in diameter, with orange epithecium and distinct thalline margin, which, however, gradually sinks below the level of the epithecium. The light hyaline spores are polar-bilocular; parathecium and amphithecium are colourless, and green gonidia are found under the hypothecium.

This plant is very nearly related to *Placodium coralloides*, Tuck. (*Synopsis of the North American Lichens*, i. p. 169), and *P. cladodes*, Tuck. (*loc. cit.*). It differs from the latter by having colourless spores in each ascus instead of one brown one. It is also stouter and bigger than both species of Tuckerman. I have only seen specimens of *P. coralloides*. The big apothecia of *P. regale* also retain their amphithecium throughout life.

Placodium regale is an interesting plant which belongs to the subgenus *Thamnoma* of *Placodium*, created by Tuckerman for his species *coralloides* and *cladodes*. The thallus is throughout distinctly diploblastic, the protothallus being easily separated from the podetia, even when the latter are prostrate, near the margin of the plants.

Several species of *Placodium* have a tendency to become fruticulose. Thus in H. Lojka Lich. Regni Hung. exsic. i. (1882), n. 26, *Lecanora elegans* Lk. v. *compacta* (Arn.) Nyl. (= *Placodium*) shows fruticulose podetia in the centre of the thallus.

Xanthoria lychnea (*Ach.*), *Th. Fr.*, North and South America, North Asia and Europe. A number of small plants were found between some podetia of *Placodium regale*. Rocks in Scotia Bay, South Orkneys.

Some fragments of crustaceous lichen are amongst the material brought from the South Orkneys, which, however, it is impossible to identify at present.

But disregarding these, we have before us, brought back by the Scottish National

Antarctic Expedition, 11 species from the South Orkneys. It is difficult with these few specimens to draw any conclusions, but it is interesting to note that all except *Placodium regale* are found in the Arctic regions, and 5 are more or less Alpine.

In a paper on the Greenland lichens collected by Vanhöffen (*Bibl. Bot.*, No. 42, 1897), the author of the present paper mentions that of the 286 known Greenland species, 213 were found also in Germany. Of these latter 105 (*i.e.* 49·4 per cent.) are purely Alpine species, 11 (5·1 per cent.) prefer Alpine conditions, and 97 (45·5 per cent.) are equally at home on the hills and in the plains. That is to say, 54·5 per cent. are typical hill species, and none of the Greenland lichens found in Germany are confined to the lowlands. The lichen vegetation of the former very closely corresponds, therefore, to the German Alpine flora.

We have not enough material to make such a complete comparison of the Antarctic lichens, but I would like to give some statistics attempted with the lichens brought back by H.M. discovery ships *Erebus* and *Terror* in the years 1839–43. These number about 124, and 44 are apparently extra-European. But of the remaining 80 species, which also occur in Europe, 2·5 per cent. are typical lowland plants, 23·75 per cent. typical Alpine plants, 66·25 per cent. are found on hillside and in lowland equally, 7·5 per cent. are exclusively Arctic, but of all the Antarctic and European species 73·75 per cent. occur also in the Arctic regions. Even the small material before us therefore admits of some interesting reflections on the great similarity between the Arctic, Alpine, and Antarctic regions in their lichen vegetation.

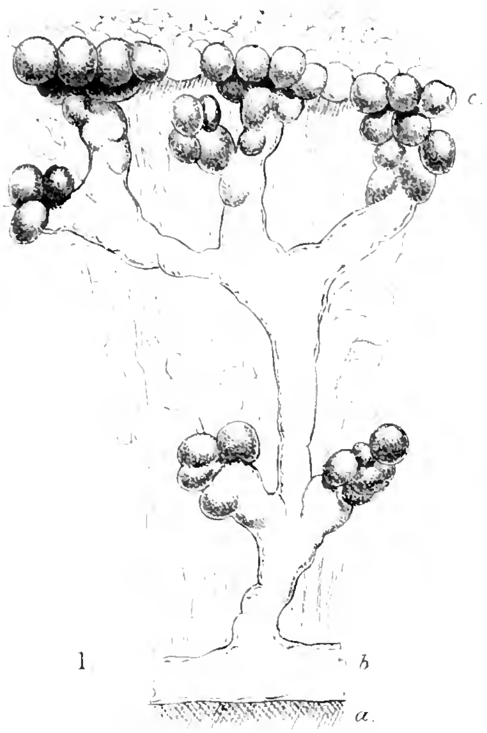
We can imagine the ancient polar floras having been continuous at one period, and then, with the decrease in the cold of the climate, the lichens followed the retreating ice and snow into the hills and the Arctic and Antarctic regions.

We find further evidence for this when we compare the most highly developed and therefore oldest lichens with the lower and therefore more recent forms, in regard to their distribution in the Arctic and Alpine zones. Of the Greenland fruticulose lichens 5·5 per cent. alone are unknown in Germany, of the foliose forms 14·3 per cent., and of the lower crustaceous forms as many as 35·6 per cent. But no special notice is taken of those species which occur in the regions lying between Greenland and the German Alps. A still more interesting comparison could be made by comparing the Antarctic lichens of America with the Alpine forms of the same continent and the Arctic lichens, but as yet the material at our immediate disposal makes this impossible.

These few remarks do favour the view that a very close relationship does exist between the Arctic and Antarctic lichens, which, however, must date back to the time when they were still constituents of one flora.

It will be seen from this that further collections of Antarctic lichens would be of very great interest.

DARBISHIRE: SOUTH ORKNEY LICHENS—PLATE I.



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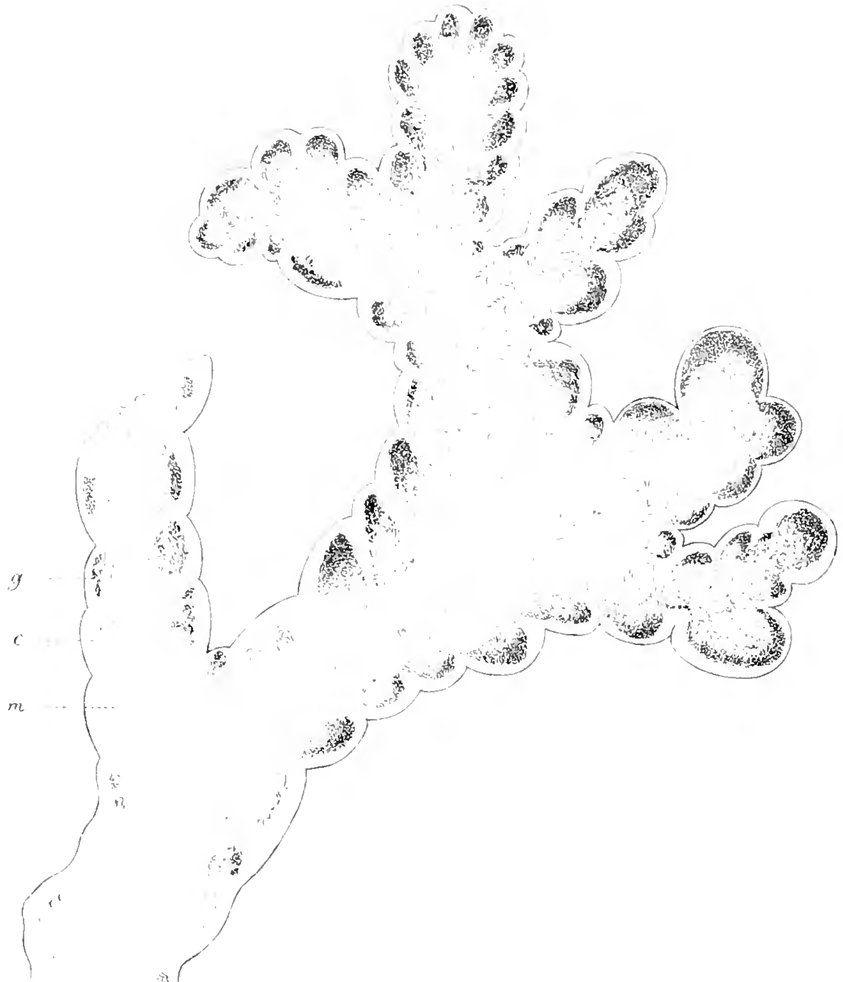

2.

O. V. Darbishire del. McFarlane & Erskine Edinr

PLACODIUM REGALE, Wainio.

EXPLANATION OF THE PLATE.

Placodium regale, Wainio.

Fig. 1. An upright podetium showing the small knob-like assimilators, which, at the top, *c*, form the roof, which gives this lichen a crustaceous appearance. *a*, substratum; *b*, protothallus; *c*, top of podetium. × 8.

" 2. Longitudinal section of a similar podetium, showing the distribution of the gonidia, *g*, in the rounded projecting assimilators. *m*, medullary, *c*, cortical portion, *g*, gonidia. × 12.

III.—THE BOTANY OF GOUGH ISLAND.

III.—THE BOTANY OF GOUGH ISLAND.[1]

By R. N. Rudmose Brown, D.Sc.; C. H. Wright, A.L.S., Royal Botanic Gardens, Kew; and O. V. Darbishire, B.A., Ph.D., University of Bristol.

(*With Four Plates.*)

Gough Island, or Diego Alvarez, which lies in the mid-South Atlantic (lat. 40° 20′ S., long. 9° 56′ 30″ W.), may be regarded as the most outlying island of the Tristan da Cunha group. It lies S.E. by S. about 220 miles from Nightingale Island, the nearest adjacent island of the group.

It is a small island some seven or eight miles in a northerly and southerly direction, and three or four miles east and west. It rises to a height of about 4000 feet.

The island has never been permanently inhabited, though the islanders of Tristan da Cunha appear occasionally to have visited it according to Mr Moseley.[2]

From August 1888 to January 1889 a party of twelve men belonging to a New London sealing schooner lived there. One of these men (George Comer), who appears to have had some knowledge of science, besides bringing home some bird skins and eggs, kept a diary in which are a few notes relating to plants. Comer[3] says "there are two kinds of trees, though while one is plentiful, the other is quite scarce. The grass and brakes grow very rank." "Wood is plentiful. The trees are stunted, but quite thick in some places on the island." "The trees retain their leaves the year round." "The thick bushes extend to an elevation of about 2000 feet." The tree referred to is no doubt *Phylica nitida*, while possibly the other "tree" is the tree-fern *Lomaria Boryana*. Comer also states that he found some potatoes growing wild "where there used to be a camp of sealers eighteen years ago." Near the landing-place, on what is apparently the only piece of level ground near sea-level, ruins of one or two huts are to be seen. These, I afterwards found at Cape Town, had been inhabited in the year 1892 by a party of sealers from South Africa who had spent thirteen months on the island. The sealing had proved a comparative failure, and the men had not returned. South Sea whalers have occasionally touched here and even brought back collections of birds and rocks, but no plants seem to have been gathered. These whalers, chiefly American, are no doubt responsible for several introduced plants on

[1] Reprinted with corrections and additions from *Journ. Linn. Soc. Lond., Bot.*, xxxvii., 1905, pp. 238–250 and pp. 263–267.

[2] H. N. Moseley, *Journ. Linn. Soc. Lond., Bot.*, xiv., 1872, p. 384.

[3] G. E. Verrill, *Trans. Conn. Acad.*, ix., 1895, part ii. p. 132.

the island. All that was previously known of the botany of Gough Island was the statement of the Tristan da Cunhans that *Phylica* grew there, and that several of the other plants were similar to the Tristan species.

The Scottish National Antarctic Expedition, on its return from the Antarctic regions in April 1904, made a stay of three days off this island; but only on one (April 22nd) was it possible, owing to the high sea running, to effect a landing, and even on that day it was only accomplished with difficulty. The extremely bad anchorage and the squally nature of the wind made it imperative that the shore-party should keep within easy reach in the event of a sudden recall being necessary. This was unfortunate, since it prevented a visit to the higher ground, where several other species might have been found. On approaching the island one is struck by the amount of green to be seen: from the highest summit to the water's edge the island seems to be clothed with vegetation, and even the steepest precipices, in which the land usually meets the sea, have their covering of moss.

Rainfall is probably great, as evidenced in the cascades of water pouring over the cliffs on all sides. Comer notes incessant strong gales, with mist, rain, and snow, in the meteorological log he kept while on the island, but he apparently took very few readings of the air temperature. Probably, however, the climate of Gough Island is very similar to that of Tristan da Cunha, where the temperature varies from 48° F. in winter to 74° F. in summer, and the precipitation is excessive the whole year round. At the time of our visit there was no snow-cap on the summit.

On the eastern side of the island a torrent coming down to the sea has cut a deep glen, and this seems to afford the only practicable road to the interior. It was here that a landing was effected.[1]

On landing, one notices the rankness of the vegetation. Above high-water, docks (*Rumex frutescens*) and the wild celery grow in luxuriant profusion, and in more stony ground I found several plants of the sow-thistle (*Sonchus oleraceus*)—these latter in flower. The tussock-grass (*Spartina arundinacea*) was not, at the place of landing, so abundant as in other parts of the coast, but here and there on the hillsides down to the sea-level there were large tufts of it. In habit it is very similar to the tussock-grass of the Falkland Islands, but does not appear to grow in such masses as almost entirely to exclude other plants as it does on those islands. The only sward-forming "grass" seems to be *Scirpus* (spp.): on the southern side of the stream was about half an acre of this, making a rich pasture. Other grasses are to be found, but growing in more isolated tufts. The characteristic tree of the Tristan da Cunha group (*Phylica nitida*) is well represented, and grows on Gough Island from about 2000 feet to sea-level, but above 100 feet it is most plentiful. The tree grows some 20 or 30 feet in height even on the most exposed ridges. The stems are not very thick, not more than 10 to 12 inches, and the branches are long and straggling, with leaves only at the extreme ends. Most

[1] For a fuller account of Gough Island see "Diego Alvarez, or Gough Island," R. N. Rudmose Brown, *Scot. Geog. Mag.*, xxi., 1905, pp. 430–440.

of the branches are thickly encrusted with lichens. Tree-ferns grow in the rich ground beside the stream, and reach a height of 4 feet or more. The beach is thickly strewn with water-worn stems of these ferns, which have probably been brought down by the stream when in spate, carried into the sea, and washed up on to the beach. Several species of ferns grow in nooks and crannies of the moist rocks, and apparently obtain an easy footing in the relatively soft volcanic ash. Mosses are plentiful everywhere, and in the bed of the stream I got several specimens of a liver-wort.

The only plants in flower were *Sonchus oleraceus* and *Apium australe* and two species of *Rumex*, and the majority even of these were in seed. *Gnaphalium pyramidale* bore withered flowers, and *Phylica nitida* and *Empetrum nigrum*, var. *rubrum*, were in fruit in a few places.

I found no trace of any plants introduced for cultivation by the settlers whose ruined huts we found. Beyond the huts was half an acre of ground beset with tree-stumps, the remains, no doubt, of the native tree which had been cut down for firewood.

The phanerogams and ferns of Gough Island, as might be expected, have proved to be very similar to those of Tristan da Cunha. The present collection contains 17 species of phanerogams and 10 of ferns. Four of the 17 species of phanerogams are almost without doubt introduced (*Hypochæris glabra*, *Sonchus oleraceus*, *Rumex obtusifolius*, and *Plantago major*). Of the remaining 23 species of Gough Island plants, 20 are recorded from Tristan da Cunha—one (*Hydrocotyle leucocephala*) is a South American plant and two are endemic (*Cotula*, sp. nov., and *Asplenium*, sp. nov.). Of the 18 species also recorded from Tristan da Cunha, four certainly, and probably six, are endemic to the group. The mosses collected by me at Gough Island comprise 21 species, of which 11 are new. A discussion of the affinities of the Gough Island flora as exhibited by the mosses is contained in Dr Cardot's paper in the present volume (pp. 57–66). Excluding the 11 endemic species and one which is only generically determined, but which is probably new, 9 species remain. Of these two are more or less cosmopolitan, and four others are of wide distribution in the southern hemisphere, so that their presence in Gough Island proves little from a geographical point of view. Two species occur in both Gough Island and Tristan da Cunha, and one in Gough Island and Ascension. One would expect the relationships to Tristan da Cunha to be more marked, and I agree with Dr Cardot that further exploration will probably prove this to be the case. Otherwise the Fuegian affinities are most marked in the moss flora of Gough Island, but I do not feel that our knowledge of that flora is anything like adequate enough to justify our drawing from it any deductions of a geographical nature regarding former land connections. For though, as Dr Cardot points out, 6 of the 9 extra-Gough Island species are found in Fuegian lands, their cosmopolitan nature or wide distribution in high southern latitudes militates against their being used as evidence in this respect. Nor must it be forgotten that a species of wide distribution in high southern latitudes would most likely be found in Fuegian lands, owing to the greater land area available there than elsewhere.

In conclusion, I have to thank the authorities at Kew and the British Museum for the facilities granted me for working in their herbaria; and Dr O. V. Darbishire and Mr C. H. Wright for their respective shares in this paper. To the late Mr C. B. Clarke I am particularly indebted for his determination of the species of *Scirpus*; and I would express my thanks to Mr A. N. Bruce, B.Sc., for the care and trouble he has taken in the drawing of the plate of *Cotula goughensis*.

I. PHANEROGAMÆ.

By R. N. Rudmose Brown, D.Sc.

Dicotyledones.

Phylica nitida, *Lam. Encycl.*, ii. p. 77; *D.C. Prodr.*, ii. p. 35; *Hemsl. Chall. Bot.*, i. II. p. 148, t. 25. P. arborea, *Thou. Esq. Fl. Trist.*, p. 45. P. mauritiana, *Boj. ex Baker, Fl. Maurit.*, p. 53.

Very common on the island up to a height of about 2000 feet, growing even on the most exposed ridges. It seldom grows more than some 25 feet in height, and the stems are always much bent and gnarled and generally covered with a growth of lichens.

Distribution.—Tristan da Cunha, Inaccessible and Nightingale Islands, Amsterdam Island, Réunion and Mauritius.

Hydrocotyle leucocephala, *Cham. et Schlecht. in Linnæa*, i. (1826), p. 364.

Common in the glen in swampy places under waterfalls. This species differs from *Hydrocotyle capitata*, Thouars—the Tristan da Cunha plant—in the almost total absence of hairs on the leaves and leaf-stalks, except an occasional sparse covering near the blade.

Distribution.—Brazil and Paraguay. This species does not appear to have been recorded outside these two countries.

Apium australe, *Thou. Esq. Fl. Trist.*, p. 43; *Hook. f. Handb. Fl. N. Zeal.*, p. 90; *Hemsl. Chall. Bot.*, i. II. p. 149.

Common on the low-lying ground down to high-water mark and growing very rankly in places. It appears to be a very variable plant, and the Gough Island variety has the leaves broadly ovate, and not linear like the specimens from Tristan da Cunha of Carmichael and Moseley.

Distribution.—Tristan da Cunha and Inaccessible Island, and very generally in extra-tropical regions of the southern hemisphere.

Nertera depressa, *Gaertn. Fruct.*, i. p. 124, t. 26; *Hook. f. Handb. Fl. N. Zeal.*, p. 120; *Hemsl. Chall. Bot.*, i. II. p. 150.

Erythrodanum alsineforme, *Thou. Esq. Fl. Trist.*, p. 42, t. 10 (Nertera).

Common in the drier and more barren places.

Distribution.—Tristan da Cunha and Inaccessible Island, and southern temperate regions except South Africa.

NERTERA DEPRESSA, *Gaertn.*, var. OBTUSA, *Rud. Br.*, var. nov.

A variety distinct from the normal *Nertera depressa* in having all its leaves obovate with no suggestion of acuteness.

Among the specimens of *Nertera depressa* gathered on Gough Island only one plant of this variety was found. In the Kew Herbarium there is one specimen from Inaccessible Island (*Moseley*, Inaccessible Island, 16.8.73) of this variety. The other specimens of this plant from Tristan da Cunha belong to the typical *Nertera depressa*, and the variety does not appear to occur elsewhere.

Distribution.—Inaccessible Island.

GNAPHALIUM PYRAMIDALE, *Thou. Esq. Fl. Trist.*, p. 40; *D.C. Prodr.*, vi. p. 234; *Hemsl. Chall. Bot.*, i. II. p. 151, t. 26. G. Thouarsii, *Spreng. Syst. Veg.*, iii. p. 473.

Common up the glen.

Distribution.—Tristan da Cunha and Inaccessible Island.

COTULA GOUGHENSIS, *Rud. Br.*, sp. nov. (Plate IV.)

Herba annua erecta vel suberecta, 25 cm. alta inferne multe ramosa; folia sessilia fere amplexicaulia, bipinnatisecta, segmentis lanceolatis in apicem acutum rotundatis; capitula folia non superantia, 8 mm. lata; involucri bracteæ late ovatæ vel fere rotundatæ, marginibus integris; flores dimorphi exteriores ♀ uniserrati sine corollis, interiores cum corollis; achenia compressa glabra.

This species is quite distinct in its much blunter leaves and broad involucral bracts from the Nightingale Island species, *Cotula Moseleyi*. It is near *Cotula coronifolia*, but differs in having broad bracts and a smaller inflorescence. *Cotula coronifolia* is also in general a much coarser plant. The only species of *Cotula* near this species as regards the broad bracts is *Cotula integrifolia*, but in other respects this is quite distinct.

Endemic in Gough Island, where it is very plentiful.

HYPOCHŒRIS GLABRA, *Linn. Sp. Pl.*, 810; *D.C. Prodr.*, vii. p. 90.

Very probably an introduced plant here, as Mr Hemsley considers it to be in Tristan da Cunha.

Distribution.—Almost cosmopolitan.

SONCHUS OLERACEUS, *Linn. Sp. Pl.*, 792.

Common: probably introduced.

Distribution.—Tristan da Cunha and Inaccessible Island, and generally throughout temperate regions.

RUMEX OBTUSIFOLIUS, *Linn. Sp. Pl.*, 335.

Probably introduced. It has not been recorded previously from the Tristan da Cunha group.

Distribution.—Very widely spread in northern and southern hemispheres.

RUMEX FRUTESCENS, *Thou. Esq. Fl. Trist.*, p. 38; *D.C. Prodr.*, xiv. p. 72; *Hemsl. Chall. Bot.*, i. II. p. 154, t. 30.

Very common at the mouth of the glen down to high-water mark.

Distribution.—Tristan da Cunha and Inaccessible Islands.

EMPETRUM NIGRUM, *Linn. Sp. Pl.*, 1022; var. RUBRUM, *Hemsl. Chall. Bot.*, i. II. p. 154. E. rubrum. *Vahl, in Willd. Sp. Pl.*, iv. p. 713; *Hook. f. Fl. Antarct.*, ii. p. 345. E. medium, *Carmich. in Trans. Linn. Soc. Lond.*, xii. (1818), p. 508.

Plentiful in dryer places.

Distribution.—Tristan da Cunha, Inaccessible and Nightingale Islands, and in the Falkland Islands and Tierra del Fuego.

PLANTAGO MAJOR, *Linn. Sp. Pl.*, 112.

Common and doubtless introduced.

Distribution.—Generally throughout the northern hemisphere, and introduced widely elsewhere.

MONOCOTYLEDONES.[1]

SCIRPUS THOUARSIANUS, *Schult. Mant.*, ii. (1824), pp. 84 et 538; *Hemsl. Chall. Bot.*, i. II. pp. 156–158, tt. 33 et 34. S. prolifer, *Thou. Esq. Fl. Trist.*, p. 36, t. 7. S. squarrosa, *Spreng. Syst. Veg.*, iv. (1827), p. 28; *Boeck. in Linnæa*, xxxvi. (1869–70), p. 507. S. Thouarsianus, *Schult.*, var. bicolor, *Hemsl. Chall. Bot.*, i. II. p. 156, t. 34 (8–16). S. prolifero-ramosus, *Boeck. in Flora*, lviii. (1875), p. 261. S. virens, *Boeck. in Flora*, lviii. (1875), p. 260; *Hemsl. Chall. Bot.*, i. II. p. 158, t. 33 (7–12). S. pallescens, *Boeck. ex Hemsl. Chall. Bot.*, i. II. p. 158. S. Thouarsianus, *Schult.*, var. pallescens, *Hemsl. Chall. Bot.*, i. II. p. 158, t. 33 (1–6).

Isolepis prolifera, *Carmich. in Trans. Linn. Soc. Lond.*, xii. (1818), p. 503. I. squarrosa, *Carmich.*, *loc. cit.*, xii. (1818), p. 503. I. bicolor, *Carmich.*, *loc. cit.*, xii. (1818), p. 503; *Kunth, Enum.*, ii. p. 216. I. acugnana, *Schult. Mant.*, ii. (1824), p. 532; *Kunth, Enum.*, ii. p. 216. I. Thouarsii, *A. Dietr. Syn. Pl.*, ii. p. 109; *Kunth, Enum.*, ii. p. 216.

Very common.

Distribution.—Tristan da Cunha, Inaccessible and Nightingale Islands.

SCIRPUS SULCATUS, *Thou. Esq. Fl. Trist.*, p. 36, t. 7; *Hemsl. Chall. Bot.*, i. II. p. 155 (*var.* Moseleyanus *excl.*), t. 31. S. Thouarsii, *Spreng. Syst. Veg.*, iv. (1827), p. 27. S. conspersus, *Boeck. in Linnæa*, xxxvi. (1869–70), p. 505, pro parte.

Isolepis sulcata, *Carmich. in Trans. Linn. Soc. Lond.*, xii. (1818), p. 503; *Kunth, Enum.*, ii. p. 216. I. Carmichaeli, *Dietr. Syn. Pl.*, ii. p. 107.

Not uncommon.

Distribution.—Tristan da Cunha group only, unless the New Zealand plant *Scirpus sulcatus* var.? *β. tristigmatosa*, C. B. Clarke, MSS., can be regarded as truly belonging to this species.

[1] For the determination of the species of *Scirpus* I am indebted to the late Mr C. B. Clarke.

SCIRPUS MOSELEYANUS, *Boeck. in Flora*, 1875, p. 262. S. sulcatus, *Thou.*, var. Moseleyanus, *Hemsl. Chall. Bot.*, i. II. p. 155, t. 32 (fig. 6 excl.).

Only one specimen of this was gathered, but fortunately it was in fruit. The ripe fruits were previously unknown.

Distribution.—Nightingale and Inaccessible Islands.

SPARTINA ARUNDINACEA, *Carmich. in Trans. Linn. Soc. Lond.*, xii. (1818), p. 504; *Kunth, Enum.*, i. p. 279; *Hemsl. Chall. Bot.*, i. II. p. 160, t. 25.

Ponceletia arundinacea, *Thou. Esq. Fl. Trist.*, p. 36.

This is one of the predominant plants of the island, apparently growing luxuriantly everywhere up to an elevation of over 1000 feet.

Distribution.—Tristan da Cunha, Inaccessible and Nightingale Islands, and St Paul and Amsterdam Islands.

POA ANNUA, *Linn. Sp. Pl.*, p. 68.

A few plants of this were found near the ruined huts of some sealers. It is no doubt introduced as it is on Tristan da Cunha.

Distribution.—Very widely spread.

II. CRYPTOGAMÆ.

FILICES.

By R. N. RUDMOSE BROWN, D.Sc.

ADIANTUM ÆTHIOPICUM, *Linn. Sp. Pl.*, ed. II. p. 1560; *Thou. Esq. Fl. Trist.*, p. 34; *Hook. and Baker, Syn. Fil.*, p. 123; *Hemsl. Chall. Bot.*, i. II. p. 163. A. thalictroides, *Willd. ex Kunze, in Linnæa*, x. (1836), p. 530. A. crenatum, *Poir. in Lam. Encyc. Suppl.*, i. p. 137. A. Poiretii, *Wikstr. in Kon. Vet.-Akad. Handl. Stock.* (1825), p. 443.

Very plentiful in the glen.

This is a very variable plant, and the Gough Island plant shows several varieties. Until a satisfactory monograph of the genus appears, it seems preferable to include all the Gough Island specimens under the name of *Adiantum æthiopicum*.

Distribution.—Tristan da Cunha and Inaccessible Island; Central and South America (except the extreme south), South Africa, India, and New Zealand.

PTERIS INCISA, *Thunb. Prodr. Fl. Cap.*, p. 133; *Hook. and Baker, Syn. Fil.*, p. 172; *Hemsl. Chall. Bot.*, i. II. p. 163. P. vespertilionis δ. Carmichaeliana, *Agardh, Rec. Sp. Gen. Pter.*, p. 80. P. vespertilionis β, *R. Br. ex Carmich. in Trans. Linn. Soc. Lond.*, xii. (1818), p. 513.

Growing in dryer places than the preceding plant; not very common.

The Tristan da Cunha specimens of this widely spread species differ from others in the fact that the veins of the fronds do not anastomose at all (*vide* Hook. and Baker, *Syn. Fil.*, p. 172). The Gough Island plants belong to the same variety.

Distribution. — Tristan da Cunha, Nightingale and Inaccessible Islands; also tropical and temperate South America, South Africa to West Tropical Africa, and from the Himalayas to New Zealand and Polynesia.

Lomaria alpina, *Spreng. Syst. Veg.*, iv. p. 62; *Hook. f. Fl. Antarct.*, ii. p. 393, t. 150; *Hook. and Baker, Syn. Fil.*, p. 178; *Hemsl. Chall. Bot.*, i. ii. p. 164. L. antarctica, *Carmich. in Trans. Linn. Soc. Lond.*, xii. (1818), p. 513.

Acrostichum polytrichoides, *Thou. Esq. Fl. Trist.*, p. 32, t. 2 (A. polypodoides).

Polypodium Pennamarina, *Poir. in Lam. Encyc.*, v. p. 520.

Not uncommon in the glen.

Distribution.—Tristan da Cunha and South America, including the Falkland Islands and Staten Island, Australia, New Zealand, Marion Island, Kerguelen, the Crozets, St Paul and Amsterdam Islands.

Lomaria Boryana, *Willd. Sp. Pl.*, v. p. 292; *Hook. and Baker, Syn. Fil.*, p. 180; *Hemsl. Chall. Bot.*, i. ii. p. 163. L. magellanica, *Desv. in Mag. Nat. Berl.* (1811), p. 330; *Hook. f. Fl. Antarct.*, ii. p. 393. L. palmæformis, *Desv. in Mém. Soc. Linn. Par.*, vi. (1827), p. 290. L. robusta, *Carmich. in Trans. Linn. Soc. Lond.*, xii. (1818), p. 512.

Pteris palmæformis, *Thou. Esq. Fl. Trist.*, p. 30.

Many specimens of this fern were found growing in marshy ground in the sheltered glen.

It reaches a height of from 2 to 3 feet, but the stems almost always grow in a procumbent position. In diameter the trunk varies from 2 inches to as much as 5 or 6.

The Gough Island plant belongs to the same variety as the Tristan da Cunha one, which Carmichael described as a new species (*Lomaria robusta*, Carmich.). It, however, only differs in having the usually naked rachis more or less densely scaly throughout, and is hardly entitled to specific rank. It must be very plentiful farther inland, as the beach is thickly strewn with waterworn stems evidently carried down by the stream from the interior and washed up again by the sea.

Distribution.—Tristan da Cunha; Tropical America to Tierra del Fuego and the Falkland Islands; South Africa, Mauritius, Réunion, and Madagascar.

Asplenium obtusatum, *Forst. f. Prod.*, p. 80; *Hook. and Baker, Syn. Fil.*, p. 207. A. obliquum, *Forst. f. loc. cit.*; *Carmich. in Trans. Linn. Soc. Lond.*, xii. (1818), p. 512. A. crassum, *Thou. Esq. Fl. Trist.*, p. 33.

Common in the glen.

This species varies a great deal, and the Gough Island plants, while agreeing with some of Moseley's plants from the Tristan da Cunha Islands, are considerably smaller than Carmichael's specimens from the same place.

Distribution.—Tristan da Cunha, Inaccessible, and Nightingale Islands. Widely distributed elsewhere.

ASPLENIUM ALVAREZENSE, *Rud. Br.*, sp. nov. (Plate IV.)

Herba parva, caudex brevis, paleis paucis sparsis; stipites 1 ad 5 cm., tenues virides nudi; frondes oblongo-deltoides bipinnatæ subcoriaceæ; pinnæ superiores sæpe in pinnulas indistincte divisæ; pinnulæ cuneatæ vel late obovatæ, margine exteriore rotundato; venæ pinnularum dichotomæ; sori mediani lineares.

This species is very near to *Asplenium Ruta-muraria*, from which it chiefly differs in having its pinnules always entire. Unfortunately none of the specimens show the sori in very good condition.

Endemic on Gough Island. It is plentiful on the stems of tree-ferns (*Lomaria Boryana*), but not common elsewhere.

POLYPODIUM AQUILINUM, *Thou. Esq. Fl. Trist.*, p. 32; *Hook. and Baker, Syn. Fil.*, p. 311; P. acunhianum, *Carmich. fide Hemsl. Chall. Bot.*, i. II. p. 167.

Nephrodium aquilinum, *Hemsl. Chall. Bot., loc. cit.*, t. 39.

Common.

Distribution.—Tristan da Cunha, Nightingale and Inaccessible Islands; Amsterdam Island (?).

POLYPODIUM AUSTRALE, *Mett. Polypod.*, p. 36; *Hook. and Baker, Syn. Fil.*, p. 322; *Hemsl. Chall. Bot.*, i. II. p. 168.

Grammitis australis, *R. Br. Prodr. Fl. Nov. Holl.*, p. 146; *Carmich. in Trans. Linn. Soc. Lond.*, xii. (1818), p. 510. G. magellanica, *Desv. Journ. Bot.*, iii. (1814), p. 275.

Only one specimen of this was found.

Distribution.—Tristan da Cunha; Tierra del Fuego, Australia, New Zealand, and Marion Island.

For the determination of this species I am indebted to Mr C. H. Wright of the Royal Gardens, Kew.

ASPIDIUM CAPENSE, *Willd. Sp. Pl.*, v. p. 267; *Hook. and Baker, Syn. Fil.*, p. 254. A. coriaceum, *Swartz, Prod. Fl. Ind. Occ.*, p. 133; *Hook. Sp. Fil.*, iv. p. 32; *Carmich. in Trans. Linn. Soc. Lond.*, xii. (1818), p. 511; *Hemsl. Chall. Bot.*, i. II. p. 167.

Polypodium calyptratum, *Thou. Esq. Fl. Trist.*, p. 33.

Fairly common.

The Gough Island specimens are larger than the Tristan da Cunha ones of Moseley, and in size approximate more to the specimen of De l'Isle's from Amsterdam Island.

Distribution.—Tristan da Cunha; America south of Cuba, South Africa, Mascarene Islands, Amsterdam Island, Australia, and Polynesia.

ACROSTICHUM CONFORME, *Swartz, Syn. Fil.*, pp. 10 and 192, t. 1, fig. 1; *Carmich. in Trans. Linn. Soc. Lond.*, xii. (1818), p. 509; *Hook. and Baker, Syn. Fil.*, p. 401; *Hemsl. Chall. Bot.*, i. II. p. 169. A. laurifolium, *Thou. Esq. Fl. Trist.*, p. 31.

Varies a little in the degree of scaliness, but the Gough Island plant is identical with other specimens from Tristan da Cunha.

Distribution.—Tristan da Cunha; St Helena, and throughout the southern hemisphere.

MUSCI.

For the mosses of Gough Island see Dr Cardot's paper, pp. 57–66 of this volume. The determinations originally published in the *Journal of the Linnean Society* (*loc. cit.*) are superseded.

HEPATICÆ.

By C. H. WRIGHT, A.L.S.

MARCHANTIA POLYMORPHA, *Linn. Sp. Pl.*, ed. II. p. 1603; *Taylor, in Lond. Journ. Bot.* (1844), p. 480; *Mont. in Voy. Pôle Sud,* "*Astrolabe,*" i. p. 211; *Mitt. in Chall. Bot.*, i. II. p. 178; *Steph. Sp. Hepat.*, i. p. 164.

Distribution.—Cosmopolitan, except that it has not been recorded from the African continent; Tristan da Cunha.

JAMESONIELLA COLORATA, *Spruce, in Journ. Bot.*, xiv. (1876), p. 202.

Jungermannia colorata, *Lehm. in Linnæa*, iv. (1829), p. 366; *Gottsche, Lindenb. and Nees, Syn. Hepat.*, p. 86; *Mitt. in Chall. Bot.*, i. II. p. 176.

Distribution.—Australia, New Zealand, South Africa, Kerguelen, Tristan da Cunha, and temperate South America; and Clarence Island, South Shetlands.

LOPHOCOLEA BIDENTATA, *Dumort. Recueil Obs. Jung.*, p. 17; *Gottsche, Lindenb. and Nees, Syn. Hepat.*, p. 159.

Jungermannia bidentata, *Linn. Sp. Pl.*, ed. II. p. 1598.

Distribution.—Cosmopolitan; recorded from St Helena, but not from Tristan da Cunha.

FUNGI.

MERULIUS AMBIGUUS, *Berk. North Amer. Fungi*, n. 175; *in Grevillea*, i. (1872) 69.

M. fugax, *Rav. Fungi Car.*, i. p. 24; *Sacc. Syll.*, vi. p. 416.

Grows on the trunks of *Phylica nitida.*

Distribution.—North America.

Du Petit-Thouars[1] mentions 4 fungi from Tristan da Cunha, among which is a species of *Merulius* which, from his imperfect description, might quite well be this species. On the other hand, it is quite likely that the American sealers who used to visit Gough Island were responsible for the introduction of this North American species.—R. N. R. B.

[1] Du Petit-Thouars, *Description abrégée des Isles de Tristan d'Acugna et Esquisse de la Flore, etc.: Mélanges de Botanique et de Voyages* (1811), p. 25.

LICHENES.

By O. V. DARBISHIRE, B.A., Ph.D.

The following is an enumeration of the 7 species of lichens brought from Gough Island by the Scottish National Antarctic Expedition, and collected there by Mr R. N. Rudmose Brown in April 1904. Of the 7 species 5 are already known as being Arctic and alpine plants :—

CLADONIA SQUAMOSA, *Hoffm. Deutsche Fl.*, ii. 152.

Cosmopolitan, but not Arctic. This plant was found in small quantities.

PARMELIA CETRATA, *Ach. Syn. Meth. Lich.*, 198.

This species was found growing on branches of *Phylica*. It is most commonly met with in more temperate parts of the world, but I do not doubt that the specimens before me, though sterile, do belong to this species.

PARMELIA SPHÆROSPORELLA, *Muell. Arg. in Flora*, lxxiv. (1891) 378.

This specimen is small and incomplete, but both in internal structure and external appearance it corresponds to the original specimen and description of J. Müller Argoviensis. He records its occurrence in the hills of Oregon.

USNEA BARBATA, *Fries, Sched. Crit. Lich. Suec.*, 34.

A number of good healthy specimens, all sterile, were brought back from Gough Island. No attempt has been made to separate out the varieties of this species. It is found in every part of the world, being common also as an Arctic plant.

RAMALINA SCOPULORUM, *Ach. Lich. Univ.*, 604.

Arctic, in Europe, Asia, and America. Gathered from rocks, and in full fruit.

PHYSCIA STELLARIS, *Nyl. Syn.*, 424.

Another cosmopolitan plant, but not typically alpine. A small specimen found growing with *Parmelia cetrata* on stems of *Phylica*.

STICTINA FULIGINOSA, *Nyl. Syn.*, 347.

Fairly common in all continents except Asia. Only a small specimen of this plant was collected on Gough Island, and it belongs, I think, to this species.

The collection also contains some fragments of a *Parmelia* plant, one of which might be *Parmelia saxatilis*, Ach., but they are too imperfect to admit of precise identification.

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EXPLANATION OF THE PLATES.

PLATE I.

Vegetation on Gough Island, showing *Phylica nitida* and *Scirpus* spp. (From a photograph by W. S. Bruce.)

PLATE II.

Vegetation on Gough Island, showing *Phylica nitida* and *Spartina arundinacea*. Waterworn stems of *Lomaria Boryana* on the beach. (From a photograph by W. S. Bruce.)

PLATE III.

Ferns on Gough Island, showing *Adiantum æthiopicum*, *Lomaria alpina*, *Acrostichum conforme*, *Polypodium aquilinum*, and *Scirpus* sp. (From a photograph by W. S. Bruce.)

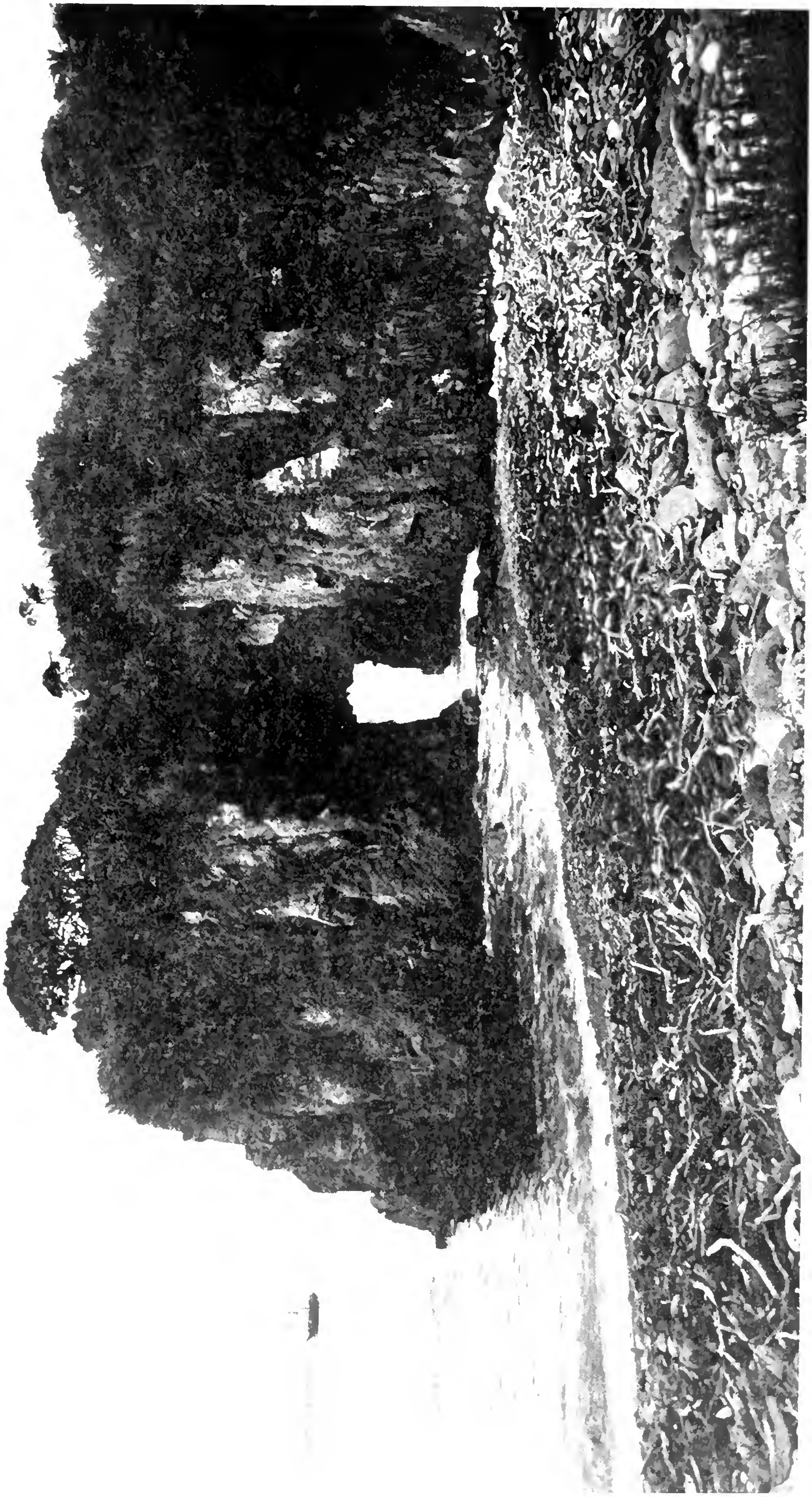
PLATE IV.

Fig. 1. *Cotula goughensis*, R. N. Rudmose Brown. Plant, nat. size.
,, 2. Apex of leaf. × 2.
,, 3. Inflorescence. × 3.
,, 4. Inflorescence with bract.
,, 5. Vertical section of inflorescence. × 6.
,, 6. Outer ♀ flower with no corolla. × 10.
,, 7. Disc-flower with corolla. × 10.
,, 8. Stamens of disc-flower. × 12.
Fig. 9. Disc-flower with corolla and stamens removed. × 10.
,, 10. Enlarged stigma. × 15.
,, 11. *Asplenium alvarezense*, R. N. Rudmose Brown. Plant, nat. size.
,, 12. Scale. Enlarged.
,, 13. Pinnule. Enlarged.
,, 14. Sporangium. Enlarged.

Rudmose Brown: Botany of Gough Island.—Plate I.

Vegetation on Gough Island.

Rudmose Brown: Botany of Gough Island.—Plate II.



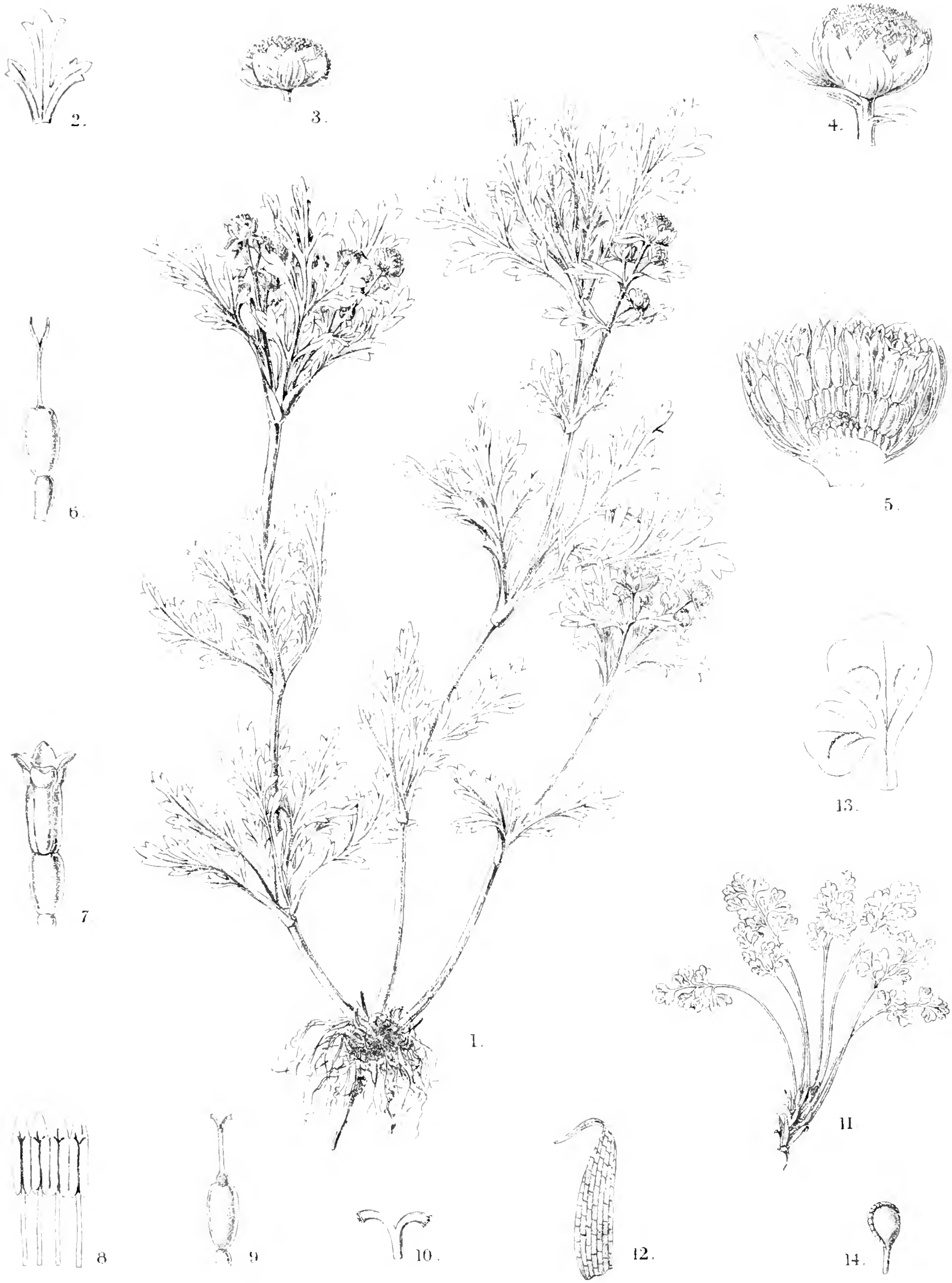
[Photo by W. S. Bruce.

Vegetation on Gough Island.

Rudmose Brown: Botany of Gough Island. Plate III.

Ferns on Gough Island.

Rudmose Brown: Gough Island—Plate IV.



A. N. Bruce del.

McFarlane & Erskine Edin.

Cotula Goughensis, Rud. Br. and Asplenium alvarezense, Rud. Br.

IV.—CONTRIBUTIONS TOWARDS THE BOTANY OF ASCENSION.

IV.—CONTRIBUTIONS TOWARDS THE BOTANY OF ASCENSION.[1]

By R. N. Rudmose Brown, D.Sc., University of Sheffield.

On the return of the Scottish National Antarctic Expedition from Cape Town to Scotland, the *Scotia* spent a few days at the island of Ascension (7° 55′ S., 14° 25′ W.), and I was enabled to make some observations and collections of botanical interest. While the earliest record of the flora of this island dates from some two centuries ago, and although it has been visited by botanists at intervals since, including Joseph D. Hooker in 1843, the first really comprehensive collections brought back were those made by H. N. Moseley, during the visit of the *Challenger* in 1876; in 1876 the German Transit of Venus Expedition in the *Gazelle* made a call at the island, and Dr Naumann collected a number of cryptogams. The results of all these expeditions are fully summarised in Mr W. Botting Hemsley's exhaustive work on insular floras,[2] which, despite the fact of its having been published in 1885, practically includes all our knowledge of the flora of Ascension until the visit of the *Scotia* in 1904.[3] The island comprises an area of some forty square miles of undulating plains lying around the base of Green Mountain, a Tertiary volcano which rises to a height of 2840 feet.

The geological constitution of the island is hard volcanic slag and some beds of volcanic ashes.[4] With the extreme dryness of the atmosphere, the want of rain, and the equability of temperature at sea-level, the low-lying ground remains almost as fresh and unweathered to-day as if its formation was a matter of only a few years ago instead of ages. The vegetation of these dry and soil-less plains is naturally very scanty; in fact, save in some exceptionally favoured spots, they are practically a desert: but that want of water is the one vital hindrance to vegetation is more clearly seen as one ascends Green Mountain. The geological structure and soil of this old volcano is, of course, essentially the same as that of the plains, but the vegetation steadily increases from the foot upwards until before 2000 feet one is pleasantly surprised to find oneself amidst a veritable oasis of rich sub-tropical vegetation. Still higher the vegetation assumes a more temperate aspect, and the top, exposed to the continually blowing

[1] Reprinted with slight alterations from *Trans. and Proc. Bot. Soc. Edin.*, xxiii., 1906, pp. 199–204.

[2] *Report on the Voyage of H.M.S. "Challenger," 1873–76: Botany*, W. B. Hemsley, i. II. p. 31 *et seq.*

[3] The German Antarctic ship *Gauss* called at Ascension in 1903, and made a small collection, which included no phanerogams. See *Deutsche Südpolar-Exp.* (*1901–03*), Bd. viii. 1906.

[4] For a fuller account of the geology of Ascension, see Darwin's *Naturalist's Voyage*.

south-east trade wind, is covered with grassland. This position of the island, in the direct track of the dry south-east trade winds, is responsible for the extremely small rainfall, which at Georgetown (sea-level) averages under 3 inches a year; but on Green Mountain, at a height of 2000 feet, where the clouds often envelop the hill, it is over 17 inches. With this very scanty rainfall the extreme desert nature of the plains is little to be wondered at, and it was only at "Wideawake Camp," the nesting-place of myriads of terns (*Sterna fuliginosa*), that much vegetation was found, which was almost entirely composed of *Portulaca oleracea*, considered to be indigenous, and the widely spread tropical grass *Setaria verticillata*, a species doubtless introduced by the action of the terns.

"Wideawake" is a hollow apparently slightly less arid than its surroundings, while, in addition, the guano of so many birds must materially assist the vegetation. *Portulaca oleracea* in places forms an almost continuous carpet, and is apparently well adapted to the prevailing conditions, for without doubt it is spreading on the island. Of the four phanerogams recorded from the island, considered by Mr Hemsley to be indigenous, I found, besides *Portulaca oleracea*, only *Euphorbia origanoides*. This endemic species is comparatively rare: near Georgetown on the "golf links" are a few stunted specimens, though on the "road" across the plains to Green Mountain I found not a few vigorous plants of it, all growing in an almost desiccated soil. Neither of the two above essentially xerophilous species finds a place in the vegetation of the higher slopes of Green Mountain. Several introduced weeds show signs of prospering, despite the adverse conditions; but the planted palms are all in an extremely miserable condition. Among the species which seem to find themselves most at home are *Vinca rosea*, *Clematis*, several species of *Physalis* and *Ricinus communis*; while several plants of *Opuntia*, planted, I believe to give some shade near the "God be thanked" water-tank on the road to Green Mountain, show every sign of spreading. In view of the essentially desert character of these plains, it is surprising to find the statement of Schimper[1] that "the island is almost completely overgrown with ferns," but this is a deduction evidently drawn from the floral statistics, which show among indigenous species a great preponderance of ferns.

Encircling Green Mountain, at a height of 2000 feet, runs Elliott's Pass—a pathway some two to three miles in length and generally cut on the slope of the hill, but often running through short tunnels where a precipice would otherwise interrupt its course. On this path, and principally in the damper localities in or about the shaded entrances to the tunnels, I collected all the cryptogams enumerated in the following list. The list contains a few new records for Ascension; and while, in the extremely altered state of the vegetation to-day, it is impossible to assert absolutely that any of these are indigenous, there is, on the other hand, no very plausible reason for considering any of them as introduced.

My collections suggest no new affinities for the flora of Ascension, which shows all

[1] *Pflanzengeographie*, A. F. W. Schimper (1908), p. 190.

evidence of long isolation, and has an indigenous flora too scanty to allow any generalisation safely to be made as to its relationships.

Finally, I must record my indebtedness to Sir W. T. Thiselton-Dyer, K.C.M.G., the late Director of the Royal Botanic Gardens, Kew, through whose kindness the hepatics and lichens were there determined.

Phanerogamæ.

Euphorbia origanoides, *Linn. Amœn. Acad.*, iii. p. 114; *Sp. Pl.*, i. 453; *Hemsl. Chall. Bot.*, i. II. p. 36.

On the dry plains between Georgetown and "Two Boats." An endemic species, but far from common.

Portulaca oleracea, *Linn. Sp. Pl.*, i. 82; *Hemsl. Chall. Bot.*, i. II. p. 34.

This species is very common on the plains, especially at "Wideawake" and vicinity, and is undoubtedly spreading on the island. It is widely spread in tropical and subtropical countries, and Mr Hemsley doubts whether it is indigenous at Ascension.

Cryptogamæ—Filices.

Polypodium reptans, *Swartz, Syn. Fil.*, p. 36; *Hook. and Baker, Syn. Fil.*, p. 316.

Elliott's Pass. Found from the West Indies to Brazil, but not previously collected at Ascension.

Polypodium trichomanoides, var. jungermannoides, *Hook. Syn. Fil.*, p. 33; *Hook. and Baker, Syn. Fil.*, p. 326; *Hemsl. Chall. Bot.*, i. II. p. 41.

Elliott's Pass: an endemic variety.

Pteris incisa, *Thunb. Prodr. Fl. Cap.*, p. 733; *Hook. Sp. Fil.*, ii. p. 230; *Hemsl. Chall. Bot.*, i. II. p. 39.

Elliott's Pass: indigenous (Hemsley). Widely distributed in the southern hemisphere, including Tristan da Cunha and Gough Island.

Asplenium lunulatum, *Swartz, Syn. Fil.*, p. 80; *Hook. and Baker, Syn. Fil.*, p. 202; *Hemsl. Chall. Bot.*, i. II. p. 40; A. alatum, *A. Rich. Sert. Astrolabe*, p. 52.

Elliott's Pass. Widely spread, including Tristan da Cunha.

Blechnum australe, *Linn. Mantissa*, i. p. 130; *Hook. Sp. Fil.*, p. 56; *Hemsl. Chall. Bot.*, i. II. p. 39.

Elliott's Pass. Distributed from St Paul and Madagascar through South Africa to Tristan da Cunha.

Nephrodium molle, *Desv. in Mém. Soc. Linn. Paris*, vi. p. 258; *Hook. Sp. Fil.*, iv. p. 67; *Hook. and Baker, Syn. Fil.*, p. 293; *Hemsl. Chall. Bot.*, i. II. p. 40.

Elliott's Pass. Widely spread, including St Helena.

PELLÆA HASTATA, *Link. Sp. Fil.*, p. 60; *Hook. and Baker, Syn. Fil.*, p. 152.

Elliott's Pass: new record for Ascension. Extends from South Africa to the Mascarene Islands eastward and the Cape Verdes northward.

LYCOPODIACEÆ.

LYCOPODIUM CERNUUM, *Linn. Sp. Pl.*, i. 1103; *Hemsl. Chall. Bot.*, i. II. p. 38; L. Boryanum, *A. Rich. Sert. Astrolabe*, p. 52.

Elliott's Pass and summit of Green Mountain. Very widely spread.

MUSCI.

The mosses of Ascension are considered in Dr Cardot's paper on pp. 66–68 of this volume. The determinations originally published in *Trans. and Proc. Bot. Soc. Edin.* (*loc. cit.*) are superseded.

HEPATICÆ.

TARGIONIA HYPOPHYLLA, *Linn. ex Rich. Voy. Astrolabe, Bot.*, p. 51; *Hemsl. Chall. Bot.*, i. II. p. 45.

Elliott's Pass: an endemic species, but one very nearly related to *T. michelii*, Corda., which is widely diffused.

PLAGIOCHASMA LIMBATUM, *Nees. in Hemsl. Chall. Bot.*, i. II. p. 44; Fegatella limbatum, *Tayl. in Hook. Lond. Journ. Bot.* (1845), p. 95.

Elliott's Pass: a new record for Ascension; previously known from St Helena.

LOPHOCOLEA, aff. LENTA, *Gottsche, Lind., and Nees.*

MASTIGOPHORA (SENDTNERA) LEIOCLADA, *Mitt. in Melliss' St Helena*, p. 370; Jungermannia leioclada, *Tayl. in Hook. Lond. Journ. Bot.* (1845), p. 85; *Gottsche, Lind., and Nees. Syn. Hepat.*, p. 723.

Elliott's Pass: an endemic species.

HYGROLEJEUNIA PTEROTA (*Tayl.*), *Steph.*; Lejeunia pterota (*Tayl.*), *Gottsche, Lind., and Nees. Syn. Hepat.*, p. 367; Jungermannia pterota, *Tayl. in Hook. Lond. Journ. Bot.* (1845), p. 91.

Elliott's Pass. Known also from St Helena.

LICHENES.

THELOSCHISTES FLAVICANS, *Norm.*; Physcia flavicans, *D.C. Fl. France*, vi. p. 189; *Nyl. Syn. Lich.*, i. p. 406; *Melliss' St Helena*, p. 376; *Hemsl. Chall. Bot.*, i. II. p. 47.

Elliott's Pass. A widely-spread species.

PHYSCIA ADSCENSIONIS, *Crombie* (Lecanora adscensionis) *in Journ. Linn. Soc. Lond.*, xvi. p. 212 ; *Hemsl. Chall. Bot.*, i. II. p. 47 ; Zahlbruckner, *Deutsche Südpolar-Exp.*, *Flechten*, Bd. viii. p. 27.

Elliott's Pass. Probably endemic, but reported also from the Cape Verde Islands (Hemsley).

PHYSCIA sp.—This is an indeterminable specimen.

CLADONIA sp.—This specimen is likewise indeterminable.

ALGÆ.

TRENTOPOHLIA POLYCARPA, *Nees. et Mont. Voy. de la Bonite, Bot.*, p. 16 ; *De Toni, Syl. Alg.*, p. 238.

A new record for Ascension. Known previously from Brazil to Fuegia and Staten Island.

V.—LES MOUSSES DE L'EXPÉDITION NATIONALE ANTARCTIQUE ÉCOSSAISE.

V.—LES MOUSSES DE L'EXPÉDITION NATIONALE ANTARCTIQUE ÉCOSSAISE.[1]

Par Jules Cardot, Charleville.

(*Avec trois Planches.*)

Avertissement.

Les Mousses rapportées par l'Expédition nationale antarctique écossaise ne sont pas très nombreuses, mais elles présentent cependant de l'intérêt, parce que la plupart proviennent de localités qui étaient restées jusque là totalement inexplorées. Le plus grand nombre des espèces a été récolté a l'île Gough ou Diego Alvarez, dont la florule bryologique était tout à fait inconnue; les récoltes de M. le Dr R. N. Rudmose Brown nous ont fourni 21 espèces pour cette petite île. Dix espèces ont été recueillies à l'île Laurie, l'une des Orcades méridionales, dans la région antarctique proprement dite; enfin, 6 espèces proviennent de l'Ascension.

Nous étudierons séparément les espèces de ces trois localités. Des listes provisoires, mais incomplètes et partiellement inexactes, ont été publiées en 1905 et en 1906 par M. C. H. Wright, dans *Linnean Society's Journal* et dans *Transactions and Proceedings of the Botanical Society of Edinburgh.*

J'ai à remercier MM. le Dr W. S. Bruce et le Dr R. N. Rudmose Brown, ainsi que les autorités du Jardin botanique de Kew, qui ont bien voulu mettre à ma disposition les matériaux de ce travail.

Charleville,
1er *décembre* 1910.

I. MOUSSES DE L'ÎLE LAURIE.[2]

L'île Laurie fait partie du groupe des Orcades méridionales, qui appartient déjà au domaine antarctique proprement dit. M. Rudmose Brown y a recueilli 10 espèces de Mousses, dont on trouvera plus loin l'énumération; mais il m'a communiqué en outre une série de 6 espèces récoltées en 1904, sur la même île, par M. L. H. Valette, de l'Observatoire météorologique de la République Argentine. Quatre des espèces rapportées par M. Valette ne se trouvant pas dans les récoltes de M. Rudmose Brown,

[1] Reprinted from *Trans. Roy. Soc. Edin.*, xlviii. 1911, pp. 67–82.

[2] Voir Cardot, "La Flore bryologique des Terres magellaniques, de la Géorgie du Sud et de l'Antarctide," pp. 243–244, *Wissen. Erg. der Schwed. Südpolar-Exp.*, 1901–03, Bd. iv. Lief 8.

le chiffre des Mousses actuellement constatées a l'île Laurie se trouve ainsi porté à 14, dont voici la liste :

Andreæa depressinervis Card.
Dicranoweisia grimmiacea Broth.
Dicranum aciphyllum Hook. fil. et Wils.
,, *Nordenskjöldii* Card.
Blindia Skottsbergii Card.
Distichium capillaceum Br. et Sch. var. *brevifolium* Br. et Sch.
Ceratodon purpureus (?) Brid.
Grimmia Antarctici Card.
,, *apocarpa* Hedw.
Webera Racovitzæ Card.
Polytrichum alpinum L.
,, *subpiliferum* Card.
Brachythecium antarcticum Card. var. *cavifolium* Card.
Drepanocladus uncinatus (Hedw.) Warnst.

Sur ces 14 espèces, aucune n'est spéciale à l'île Laurie, mais 4 : *Andreæa depressinervis*, *Grimmia Antarctici*, *Webera Racovitzæ* et *Brachythecium antarcticum*, n'ont pas été rencontrées jusqu'ici en dehors du domaine antarctique. Quant aux autres espèces, voici leur dispersion :

Dicranoweisia grimmiacea. Géorgie du Sud, Kerguelen.
Dicranum aciphyllum. Géorgie du Sud, domaine magellanique.
,, *Nordenskjöldii.* Géorgie du Sud.
Blindia Skottsbergii. Géorgie du Sud.
Distichium capillaceum. Plus ou moins cosmopolite ; domaine magellanique.
Ceratodon purpureus. Cosmopolite ; domaine magellanique.
Grimmia apocarpa. Cosmopolite ; domaine magellanique.
Polytrichum alpinum. Cosmopolite ; domaine magellanique, Géorgie du Sud, Kerguelen.
,, *subpiliferum.* Domaine magellanique.
Drepanocladus uncinatus. Cosmopolite ; domaine magellanique, Géorgie du Sud, Kerguelen.

ANDREÆACEÆ.

Andreæa.

A. DEPRESSINERVIS *Card.*, in *Rev. bryol.*, 1900, p. 43, et *Résult. voyage "Belgica," Mousses*, p. 22, pl. i., figs. 22–33.

Andreæa sp. Wright, in *Trans. and Proc. Bot. Soc. Edin.*, xxxiii., part i.

WEISIACEÆ.

Dicranoweisia.

D. GRIMMIACEA (*C. Müll.*) *Broth.*, in *Nat. Pflanzenfam.*, *Musci*, p. 318.

DICRANACEÆ.

Dicranum.

D. ACIPHYLLUM *Hook. fil. et Wils.*, in *Lond. Journ. of Bot.*, 1844, p. 541.

D. NORDENSKJÖLDII *Card.*, in *Bull. Herb. Boissier*, 2ème sér., vi. p. 14, et *Fl. bryol. Terres magell.*, etc., pp. 265–266, fig. 59.

Campylopus introflexus Wright, *loc. cit.*, non Mitt.

SELIGERIACEÆ.

Blindia.

B. SKOTTSBERGII *Card.*, in *Bull. Herb. Boissier*, 2ème sér., vi. p. 4, et *Fl. bryol. Terres magell.*, etc., p. 207, fig. 44.

Campylopus resticaulis Wright, *loc. cit.*, non Mitt.

GRIMMIACEÆ.

Grimmia.

G. APOCARPA (*L.*) *Hedw.*, *Sp. Musc.*, p. 76.

"*G. cf. apocarpa* Hedw.," Wright, *loc. cit.*

G. ANTARCTICI *Card.*, in *Bull. Herb. Boissier*, 2ème sér., vi. p. 15, et *Fl. byrol. Terres magell.*, etc., p. 271, pl. v. figs. 16–25, pl. vi. figs. 1–5.

G. amblyophylla Wright, *loc. cit.*, non C. Müll.

BRYACEÆ.

Webera.

W. RACOVITZÆ *Card.*, in *Rev. byrol.*, 1900, p. 44, et *Résult. voyage* "*Belgica*," *Mousses*, p. 35, pl. xiii. figs. 1–14.

Bryum sp. Wright, *loc. cit.*

POLYTRICHACEÆ.

Polytrichum.

P. SUBPILIFERUM *Card.*, in *Rev. byrol.*, 1900, p. 42, et *Résult. voyage* "*Belgica*," *Mousses*, p. 39, pl. xii. figs. 1–14.

HYPNACEÆ.

Drepanocladus.

D. UNCINATUS (*Hedw.*) *Warnst.*, *Beih. zum Bot. Centralbl.*, xiii. p. 417.

II. MOUSSES DE L'ÎLE GOUGH OU DIEGO ALVAREZ.

Sur les 21 espèces de Mousses récoltées à l'île Gough par M. Rudmose Brown, 11 espèces sont endémiques ; du moins, elles ne me semblent pas pouvoir être rapportées à des espèces signalées ailleurs. Un *Dicranella*, représenté seulement par la plante mâle, est indéterminable. Restent 9 espèces, sur lesquelles 6 appartiennent à la flore magellanique :

Rhacomitrium symphyodontum Jaeg. Existe aussi au Chili, en Tasmanie et en Nouvelle-Zélande.
,, *subnigritum* Par., représenté à l'île Gough par une variété endémique.
Webera nutans Hedw. } Plus ou moins cosmopolites.
,, *albicans* Sch. }
Polytrichadelphus magellanicus Mitt. Existe aussi dans la région australo-néozélandaise.
Brachythecium subpilosum Jaeg. Se retrouve encore aux îles Marion, Kerguelen, Géorgie du Sud et dans l'Antarctide.

Deux espèces se retrouvent à Tristan d'Acunha :

Rhacomitrium symphyodontum Jaeg. = *R. membranaceum* Par.
Philonotis capillata Par.

et une à l'Ascension :

Sphagnum Scotiæ Card.

Enfin, une dernière espèce : *Cyclodictyon læterirens* Mitt., existe en Irlande, à Madère et à Fernando-Po.

Les espèces endémiques montrent des affinités avec des Mousses de Tristan d'Acunha, de la région magellanique, de l'Afrique australe et même de la Réunion, de l'île St Paul et de Kerguelen, dans l'Océan Indien, mais c'est, en somme, avec la végétation de la région magellanique que la florule bryologique de l'île Gough paraît avoir le plus de rapports. Il est toutefois probable que quand les Mousses de Tristan d'Acunha et celles de l'île Gough seront mieux connues, on relèvera un plus grand nombre d'espèces communes à ces deux îles, qui présentent les plus grandes analogies quant à la flore supérieure.

SPHAGNACEÆ.

Sphagnum.

S. SCOTIÆ *Card.* sp. nova.

S. acutifolium Wright, in *Linn. Soc. Journ.*, *Bot.*, xxxvii. p. 264, non Ehrh.

Molle, pallide viride. Caulis cellulæ epidermicæ distinctæ, magnæ, bistratosæ, cylindrum lignosum pallidum, cellulis vix vel parum incrassatis formatum. Rami 3 vel 4 in singulo fasciculo, quorum 1 vel 2 penduli. Folia caulina magna, 1·75–2 millim. longa, 0·8–1 millim. lata, oblongo-lingulata, basi haud vel vix angustata, apice obtuso, integro, plus minus cucullato, superne vel fere e basi fibrosa, limbo augusto ubique æquilato marginata. Folia ramorum divergentium ovato-lanceolata, concava, 1·5–1·6 millim. longa, 0·7–0·75 lata, marginibus superne inflexis, apice truncatulo et denticulato; leucocystæ valde fibrosæ, poris majusculis, in parte superiore paginæ dorsalis secundum chlorocystas sat numerosis, in pagina ventrali nullis vel perpaucis; chlorocystæ ventrales, in sectione transversali trapezoidales, utraque pagina inter leucocystas emergentes.

Je n'ai vu que deux petits fragments de cette espèce, l'un provenant de l'île Gough, l'autre de l'Ascension. Elle est voisine du *S. Reichardtii* Hpe., de l'île St Paul, mais celui-ci a les feuilles caulinaires plus courtes, ovales et à leucocystes toutes divisées par plusieurs cloisons obliques, ce qui n'a lieu, dans l'espèce nouvelle, que sur un petit nombre de leucocystes.

DICRANACEÆ.

Trematodon.

T. INTERMIXTUS *Card.*, sp. nova.

Aliis muscis commixtus gregarie crescens. Caulis gracilis, mollis, erectus, laxifolius, 6–10 millim. longus. Folia mollia, e basi subvaginante breviter oblonga in subulam elongatam, canaliculatam, plus minus flexuosam, integerrimam vel apice minute denticulatam sat abrupte constricta, media et superiora 4·5–5·5 millim. longa, 0·6–0·75 basi lata, inferiora breviora, costa basi angusta, superne dilatata et totam fere subulam occupante, cellulis basis elongatis, linearibus, in subula brevioribus, minute rectangulis. Folia perichætialia longiora, e basi laxius reticulata magis sensim angustata. Capsula in pedicello pallide stramineo, 12–15 millim. longo erecta inclinatave, ætate arcuata, collo sporangio longiore basi strumuloso instructa, 3–4 millim. longa, operculo longirostro. Peristomii dentes auguste lanceolati, circa 0·35 millim. longi, rubro-aurantiaci, dorso longitudinaliter striati, intus papillosi, lamellis paucis ornati, usque ad basin in 2 crura apice cohærentia divisi. Sporæ luteo-virides, minute granulosæ, diam. 18–28 μ. Flores masculi gemmiformes, aggregati, terminales.

Se rapprochant par ses feuilles longuement subulées du *T. setaceus* Hpe., de l'île St Paul, cette espèce m'en paraît suffisamment distincte par sa capsule à col plus long que le sporange, et par ses dents péristomiales divisées jusqu'à la base en deux branches distinctes, plus ou moins cohérentes seulement au sommet. Les échantillons trop pauvres dont je disposais ne m'ont pas permis de reconnaître si les fleurs mâles naissent sur des tiges spéciales, ou bien au sommet de rameaux basilaires de la plante fructifère.

Dicranella.

D. SP., planta mascula.

Probablement une espèce nouvelle, dont nous n'avons malheureusement que la plante mâle. Petite Mousse de 2 à 4 millimètres, à feuilles étalées-dressées, flexueuses, planes aux bords, à subule généralement plus ou moins obtuse ou un peu tronquée et denticulée au sommet.

Campylopus.

C. ALVAREZIANUS *Card.*, sp. nova.

Cespites superne lutescentes, intus fusco-tomentosi, 1–4 centim. alti. Caulis simplex vel parce divisus, sæpe basi ramos filiformes gracillimos emittens. Folia plus minus conferta, superiora comosa, subsecunda, anguste lanceolata et sensim in subulam canaliculatam, acutam, dorso scaberulam, apicem versus dentatam, rarius subintegram protracta, 4·5–5 millim. longa, 0·5–0·65 millim. basi lata, inferiora minora, appressa, costa latissima, $\frac{1}{2}$–$\frac{2}{3}$ basis et totam fere subulam occupante, elamellosa, in sectione transversali a cellulis ventralibus majusculis, eurycystis dorso stereidis et substereidis tectis, cellulisque epidermicis dorsalibus composita, cellulis alaribus tenerrimis, hyalinis, marcescentibus, parum distinctis, cæteris lineari-rectangulis et subquadratis, parietibus incrassatis. Reliqua desiderantur.

On peut comparer cette espèce au *C. vesticaulis* Mitt., de Tristan d'Acunha, mais celui-ci est plus robuste, ses tiges sont recouvertes d'un tomentum plus abondant, et ses feuilles, plus grandes, présentent dans la partie moyenne un tissu fort différent, composé de cellules irrégulières, plus ou moins obliques, atténuées, subrhomboïdales. Le *C. alvarezianus* rappelle assez, par son aspect extérieur, le *C. eximius* Reich., de l'île St Paul, mais s'en sépare d'ailleurs complétement par ses feuilles épilifères et par son tissu.

J'ai trouvé dans les récoltes de M. Rudmose Brown quelques tiges d'un *Campylopus* à feuilles plus molles, plus flexueuses à l'état sec, et à tissu formé jusque près de la base de cellules plus courtes, carrées ou brièvement rectangulaires, qui, bien qu'assez différent de l'espèce que je viens de décrire, me semble cependant n'en être qu'une simple forme.

GRIMMIACEÆ.

Rhacomitrium.

R. SYMPHYODONTUM (*C. Müll.*) *Jaeg.*, *Ad.*, i. p. 375.

R. flavescens Card., in *Rev. bryol.*, 1900, p. 41 ; Wright, *loc. cit.*, *pro parte.*

Echantillon stérile.

La forme récoltée à l'île Gough par M. Rudmose Brown ne diffère pas de la plante magellanique, qui est très variable ; mais elle ne représente pas exactement le *R. flavescens* Card., que je ne considère plus, d'ailleurs, que comme une des nombreuses formes du *R. symphyodontum.* Le *R. membranaceum* (Mitt.) Par., de Tristan d'Acunha, ne me paraît être également qu'une forme de la même espèce, caractérisée par ses feuilles étroites et son pédicelle extrêmement court.

R. SUBNIGRITUM (*C. Müll.*) *Par.*, *Ind. bryol.*, ed. i., p. 1080. Var. *alvarezianum* Card. *var. nova.*

R. flavescens Wright, *loc. cit.*, *pro parte.*

A forma typica patagonica et fuegiana differt : colore minus nigricante, obscure vel sordide viridi, foliis majoribus, latioribus (3·3–3·75 millim. longis, 1–1·2 latis), mollioribus, siccitate minus imbricatis, marginibus minus late incrassatis, costaque validiore, basi 180–220 μ lata (loco 112–140 in forma genuina). Sterile.

Orthotrichaceæ.

Macromitrium.

M. antarcticum *Wright*, in *Linn. Soc. Journ.*, *Bot.*, xxxvii. p. 264.

Cespites densi, lutescenti-virides. Caulis repens, ramis confertis, brevissimis, subnodulosis dense pinnatus. Folia conferta, sicca cirrata, madida patenti-erecta, anguste oblongo-lanceolata vel subligulata, carinata, acuminata, acuta obtusulave, integerrima, 1–1·8 millim. longa, 0·25–0·45 lata, marginibus ubique planis vel inferne anguste reflexis, costa percurrente vel subpercurrente, cellulis omnibus lævissimis, inferioribus vermicularibus, angustissimis, parietibus perincrassatis, cæteris quadratis vel subrotundatis. Folia perichætialia intima caulinis latiora, oblongo-lanceolata. Capsula in pedicello lævi, 4–6 millim. longo, erecta, ovata, pachyderma, 1–1·25 millim. longa, 0·5–0·7 lata, ore rubro, vernicoso, siccitate plicato, operculo longirostri. Peristomium simplex, dentibus griseis, granulosis, truncatis. Calyptra nuda.

Espèce de la section *Goniostoma*, très voisine du *M. borbonicum* (Besch.) Broth., mais ayant les feuilles plus longues, les capsules et les pédicelles plus courts; elle se rapproche aussi beaucoup du *M. Seemanni* Mitt., de Ste Hélène, qui s'en distingue par son port plus robuste. sa teinte d'un jaune brun, ses feuilles plus rétrécies dans le haut, les cellules allongées occupant une plus grande partie de la feuille et s'avançant jusqu'au delà du milieu (tandis qu'elles s'arrêtent généralement au dessous du milieu dans le *M. antarcticum*), les cellules supérieures plus arrondies, à parois plus épaissies, jaunâtres, le pédicelle plus épais, et la capsule plus solide.

Bryaceæ.

Webera.

W. nutans (*Schreb.*) *Hedw.*, *Sp. Musc.*, p. 168.

Quelques tiges dépourvues de capsules, mélangées au *Campylopus alvarezianus*; inflorescence paroïque ou subsynoïque Paraît bien identique au type de l'hémisphère boréal.

W. albicans (*Wahlenb.*) *Sch.*, *Coroll.*, p. 67.

Tiges stériles, au milieu des gazons de *Philonotis capillata.* C'est une forme grêle, comme on en trouve également en Europe.

Bryum.

B. tenellicaule *Card.*, sp. nova.

Cespites tenelli, densiusculi, nitiduli, viridi-lutescentes, laxe cohærentes. Caulis gracillimus, ruber, laxifolius, parce radiculosus, 7–12 millim. altus, simplex vel parcissime divisus. Folia siccitate patenti-erecta, subflexuosa, madore patentia, caviuscula, anguste lanceolata, acuminata, costa excurrente cuspidata, 1·25–1·5 millim. longa, 0·25–0·45 lata, marginibus nunc planis, nunc reflexis vel anguste revolutis, apicem versus remote et minute denticulatis, costa valida, basi 50–70 μ lata, viridi vel lutescente, in subulam crassam, parce denticulatam vel subintegram longiuscule excedente, cellulis inferioribus rectangulis et subrectangulis, cæteris oblongo-rhomboideis. Flores fructusque desiderantur.

Cette petite espèce, de la section *Doliolidium*, peut être comparée au *B. coronatum* Schw.; elle en diffère par sa petite taille, ses tiges plus grêles, ses feuilles beaucoup plus petites, etc.

B. SUBULINERVE *Card.*, sp. nova.

Cespites densiusculi, pallide vel sordide virides. Caulis superne dense, inferne laxius foliosus, 6–12 millim. altus, dichotome divisus et subfastigiato-ramosus. Folia madida, patentia, sicca suberecta, concava, inferiora lanceolata, acuminata, superiora late ovato-lanceolata, brevius acuminata, costa longe excurrente cuspidata, 1·3–1·6 millim. longa, 0·5–0·7 lata, marginibus plerumque e basi usque apicem versus revolutis, rarius subplanis, integris vel superne sinuato-subdenticulatis, costa valida, 70–80 μ basi lata, viridi-lutescente, in subulam crassam, remote denticulatam longe excedente, cellulis mediis et superioribus oblongo-rhomboideis, parietibus crassiusculis, inferioribus breviter rectangulis et subquadratis, infimis laxis, teneris, rubellis vel subhyalinis. Cætera desiderantur.

Appartenant également à la section *Doliolidium*, cette espèce se distingue du *B. coronatum* Schw. par ses feuilles généralement révolutées, pourvues d'une nervure plus forte, formant une subule plus épaisse et plus longue, les feuilles supérieures plus larges et plus courtes.

BARTRAMIACEÆ.

Bartramia.

B. STENOBASIS *Card.*, sp. nova.

Cespites densi, lutescenti-virides. Caulis erectus, simplex, parum radiculosus, 1·5–2 centim. altus. Folia sicca et madida erecto-flexuosa vel patenti-erecta, fragilia, facillime decidua, e basi parva, angusta, vix dilatata longissime subulata, setacea, utraque pagina papillosa, 4–5 millim. longa, basi vix 0·12 lata, marginibus serrulatis, costa dilatata, in subulam dentatam, scabram exeunte, cellulis basilaribus laxis, pellucidis, elongatis, lævibus, cæteris linearibus, angustis, 2–3-stratosis, parietibus transversis prominentibus papillosis. Cætera desunt.

Rappelle assez le *B. patens* Brid., mais en diffère par ses feuilles à partie basilaire plus petite, plus étroite et moins brusquement contractée. Espèce remarquable par le peu de développement de la partie basilaire de la feuille, très différente du *B. radicosa* Mitt., de Tristan d'Acunha, qui est beaucoup plus robuste, et a les feuilles moins finement subulées, brusquement et fortement dilatées à la base, et les tiges très radiculeuses.

Philonotis.

Ph. capillata (*Mitt.*) *Par.*, *Ind. bryol.*, ed. i., p. 919.

Echantillons stériles et plante mâle.

Il y a deux formes différentes dans les récoltes de M. Rudmose Brown. L'une est complétement identique à la plante originale de Tristan d'Acunha ; l'autre est plus grêle, plus petite, d'une vert glauque, plus molle dans toutes ses parties ; mais elle ne diffère pas autrement du type. Cette dernière forme croissait intimement mélangée au *Webera albicans*, dont elle a un peu l'aspect.

Polytrichaceæ.

Polytrichadelphus.

P. magellanicus (*L.*) *Mitt.*, in *Journ. Linn. Soc.*, 1859, p. 97.

Polytrichum commune Wright, in *Linn. Soc. Journ.*, *Bot.*, xxxvii. p. 265, non Linn.

Tiges stériles, mais la structure de la feuille et des lamelles ne laisse aucun doute sur leur détermination.

Hookeriaceæ.

Cyclodictyon.

C. lætevirens (*Hook. et Tayl.*) *Mitt.*, in *Journ. Linn. Soc.*, 1864, p. 163.

Echantillon stérile, bien identique à ceux d'Irlande.

Leskeaceæ.

Thuidium.

Th. alvarezianum *Card.*, sp. nova.

Humile, gracile. Caulis primarius repens, tenellus, secundarius erectus ascendensve, 1–2 centim. longus, remote et irregulariter pinnatus et pareissime bipinnatus, paraphylliis sat numerosis, brevibus, simplicibus, papilloso-dentatis obtectus. Folia madida undique patentia, sicca incurvato-crispata, caulina e basi late cordata abrupte acuminata, 0·4–0·5 millim. longa, 0·25–0·35 lata, ramea aliquid minora, magis sensim latiuscule acuminata, 0·3–0·4 millim. longa, 0·18–0·20 lata, ramulina minima, ovato-lanceolata, 0·15–0·18 millim. longa, vix 0·08 lata, omnia caviuscula, acuta, marginibus planis, crenulatis, superne serrulatis, costa in acumine evanida, cellulis quadratis vel subrotundatis, utraque pagina papilla singula medio notatis. Cætera desiderantur.

Cette espèce se rapproche du *Th. curvatum* Mitt., de Tristan d'Acunha ; elle en diffère par sa taille plus faible, son port beaucoup plus grêle, et ses feuilles caulinaires et raméales moins dimorphes, plus petites, plus courtes et plus brièvement acuminées. Le *Th. curvatum*, que M. Brotherus place dans les *Thuidiella*, est certainement, d'après l'échantillon original que j'ai pu examiner, un *Thuidiopsis*, très voisin des

Th. unguiculatum (Hook. fil et Wils.), *furfurosum* (Hook. fils et Wils.) et *hastatum* (C. Müll.), de la Nouvelle-Zélande. C'est donc également dans la section *Thuidiopsis* que doit prendre place l'espèce nouvelle.

HYPNACEÆ.

Isopterygium.

I. BROWNII *Card.*, sp. nova.

Tenellum, intricato-repens, lutescenti-viride, nitidulum. Caulis gracillimus, 8–12 millim. longus, irregulariter ramosus, ramis complanatulis, attenuatis. Folia laxiuscula, subdistiche patentia vel sursum leniter homomalla, anguste lanceolata, sensim longeque acuminata, lateralia falcatula, obsolete binervia vel enervia, media 1·1–1·35 millim. longa, 0·25–0·37 lata, marginibus planis, superne serrulatis, cellulis anguste linearibus, mediis longissimis, alaribus perpaucis subindistinctis. Cætera desiderantur.

Cette petite espèce rappelle assez les *I. antarcticum* (Mitt.) Card. et *fuegianum* Besch. ; elle s'en distingue par ses feuilles étroitement lancéolées et terminées par un acumen moins long, moins étroit et denticulé. Elle croissait au milieu des tiges du *Bartramia stenobasis.*

A propos de l'*I. antarcticum*, je ferai remarquer que la Mousse de Kerguelen que C. Müller a décrite en 1890 sous le nom de *Hypnum* (*Plagiothecium*) *antarcticum* (*Forschungsreise S.M.S.* "*Gazelle*," *Laubmoose*, p. 34) n'est nullement le *Plagiothecium antarcticum* de Mitten, qui est un *Isopterygium*, tandis que la plante de Müller est un *Plagiothecium.* Müller reconnaissait, d'ailleurs, qu'il n'était pas certain de l'identité des deux plantes, qui, de fait, sont fort différentes. Mais le *P. antarcticum* C. Müll. non Mitt., de Kerguelen, est exactement la même chose que l'espèce décrite l'année précédente par Müller sous le nom de *Hypnum* (*Plagiothecium*) *georgico-antarcticum* ("Bryologia Austro-Georgiæ," in *Ergebn. der deutsch. Polar-Exped.*, All. Theil, Bd. ii. 11, p. 321). Les différences que l'auteur indique entre les deux plantes ne sont pas constantes et n'ont aucune valeur : le tissu des feuilles n'est pas plus chlorophylleux dans l'une que dans l'autre, et l'acumen est souvent denticulé au sommet sur la Mousse de la Géorgie du Sud. C'est l'espèce de Müller, et non celle de Mitten, que M. Brotherus a mentionnée sous le nom de *Plagiothecium antarcticum* dans son tableau synoptique du genre (in Engler et Prantl, *Pflanzenfamil.*, *Musci*, p. 1086). J'ajouterai que le *Hypnum austropulchellum* de Müller (*Forschungreise*, etc., p. 35) pourrait bien être l'espèce de Mitten.

I. AMBIGUUM *Card.*, sp. nova.

Molle, lutescens, nitidulum, robustulum, intricato-cespitosum. Caulis 2–3 centim longus, irregulariter divisus, ramis flaccidis, complanatis, obtusis. Folia compressa, distiche patentia vel subhomomalla, e basi sæpe subdecurrente oblongo-lanceolata, longiuscule et acute acuminata, lateralia aliquid asymmetrica et curvatula, 2–2·5 millim. longa, 0·5–0·75 lata, marginibus planis ubique integris vel apicem versus remote et minute denticulatis, costa gemella vel furcata, ad $\frac{1}{4}$–$\frac{1}{3}$ producta obsoletave, cellulis anguste linearibus, flexuosis, mediis longissimis, alaribus plerumque distinctis, laxis, ovatis, oblongisve, subinflatis. Cætera ignota.

En raison de ses cellules alaires ordinairement assez différenciées et souvent subdécurrentes, cette espèce occupe une place indécise entre les genres *Isopterygium* et *Plagiothecium*.

Brachythecium.

B. PALLIDOFLAVENS *Card.*, sp. nova.

Gracile, pallidoflavens, nitidulum. Caulis longe repens, flexuosus, rhizoidis fasciculatis radiculosus, irregulariter pinnatus, ramis teretibus, patulis, siccitate julaceis, breviter attenuatis. Folia ramea madida erecto-patentia, sicca erecta, subappressa, oblongo-lanceolata, sensim tenuiterque acuminato-subulata, plicata, 1·5–1·8 millim. longa, 0·35–0·5 lata, marginibus planis vel plus minus revolutis, inferne integris, superne remote et minute denticulatis, costa tenui, ad $\frac{2}{3}$ evanida, reti pallido, cellulis anguste linearibus, parietibus crassiusculis, alaribus distinctis, quadratis vel rectangulis. Folia caulina laxiora, haud vel vix plicata, costa breviore, medium versus evanida. Cætera desunt.

Cette espèce, dont je n'ai trouvé que quelques tiges en mélange avec les autres Mousses, est voisine des *B. austrosalebrosum* et *austroglareosum* (C. Müll.) Par. ; elle diffère du premier par ses dimensions plus faibles, par ses rameaux julacés à l'état sec, et par ses feuilles plus étroites, denticulées dans la partie supérieure ; elle se distingue du second par ses rameaux plus grêles, et par ses feuilles plus étroites, à bords plans ou moins régulièrement révolutés.

B. SUBPILOSUM (*Hook. fil. et Wils.*) *Jaeg., Ad.*, ii. p. 410.

Un petit échantillon stérile, dont l'attribution à cette espèce ne me paraît cependant pas douteuse.

Rhynchostegium.

R. ISOPTERYGIOIDES *Card.*, sp. nova.

R. rhaphidorhynchum Wright, in *Linn. Soc. Journ., Bot.*, xxxvii. p. 265, non *Hypnum raphidorrhynchum* C. Müll., *Syn.*, ii. p. 354.

Autoicum, lutescens, nitidum. Caulis procumbens, vage pinnatus, ramis complanatulis, isopterygioideis, obtusis. Folia caulina erecto-patentia, ramea compressula, late ovato-lanceolata, acuminata, acumine acuto plerumque semitorto, 1·5–1·75 millim. longa, 0·7–0·85 lata, marginibus planis e basi serrulatis, costa tenui, ad $\frac{2}{3}$ evanida, cellulis pellucidis, linearibus, subflexuosis, alaribus paucis, brevioribus, subrectangulis et subquadratis. Folia perichætialia intima e basi oblonga, convoluta, in acumen longiusculum serrulatum protracta. Pedicellus rubellus, lævis, 10–12 millim. longus. Cætera ignota.

Cette Mousse diffère du *R. raphidorrhynchum* (C. Müll.) Jaeg., de l'Afrique australe, par ses feuilles plus fortement dentées, terminées par un acumen moins étroit, en général à demi tordu, et par son tissu moins serré. Elle se rapproche beaucoup du *R. confertum* Br. eur., d'Europe, mais s'en distingue cependant par son port, ses rameaux comprimés, qui lui donnent l'aspect d'un *Isopterygium*, et ses feuilles plus dentées. Peut-être est-ce la même plante qui a été indiquée par Mitten à Tristan d'Acunha sous le nom de *Hypnum raphidorrhychum*.

III. MOUSSES DE L'ASCENSION.

D'après le *Bryologia atlantica*, œuvre posthume du regretté A. Geheeb, qui vient de paraître tout récemment, la florule bryologique de l'Ascension comprend 20 espèces ; ce chiffre se trouve maintenant porté à 24 par les récoltes de M. Rudmose Brown. Voici l'énumération complète de ces espèces :

Sphagnum Scotiæ Card.
Dicranella pygmæa Card.
,, *ascensionica* Mitt.
Campylopus smaragdinus (Brid.) Jaeg.
,, *introflexus* (Hedw.) Mitt.
,, *Naumanni* (C. Mull.) Par.
Calymperes Ascensionis C. Müll.
Gymnostomum Lessonii Besch.
,, *Bescherellei* Broth. et Geh.
Hyophila Ascensionis Card.
Barbula leucochlora C. Müll.
,, *cuspidatissima* C. Müll.
Bryum zygodontoides C. Müll.
,, *argentatum* C. Müll.
,, *rubrocostatum* C. Müll.
Philonotis penicillata Wright.
,, *pergracilis* Card.
,, *subolescens* (C. Müll.) Par.
Leucodon Bescherellei Broth. et Geh.
Neckera Ascensionis C. Müll.
Callicostella Ascensionis C. Müll.
Rhacopilum gracile Mitt.
,, *Naumanni* C. Müll.
Taxithelium planum Brid.

Il est fort possible que le *Rhacopilum gracile* Mitt. (1885) soit la même espèce que le *R. Naumanni* C. Müll. (1883). Le *Gymnostomum Bescherellei* est une espèce nouvelle, qui est figurée dans l'ouvrage de Geheeb ; le *Leucodon Bescherellei* est une autre espèce nouvelle, malheureusement restée à l'état de *nomen nudum*.

Sauf trois, toutes les espèces sont spéciales à l'île de l'Ascension. Les trois espèces non endémiques sont :

Sphagnum Scotiæ Card., qui se retrouve, ainsi que nous l'avons vu, à l'île Gough.
Campylopus introflexus (Hedw.) Mitt. (*C. polytrichoides* De Not.), plus ou moins cosmopolite.
Taxithelium planum Brid., espèce de l'Amérique tropicale, dont l'existence réelle à l'Ascension reste bien douteuse.

SPHAGNACEÆ.

Sphagnum.

S. SCOTIÆ *Card.* (*vide supra*, p. 4).

S. cuspidatum Wright, in *Trans. and Proc. Bot. Soc. Edinb.*, xxiii., ii. p. 203, non Ehrh.

Le petit fragment que j'ai vu provenant de l'Ascension ne paraît pas différer de la Sphaigne de l'île Gough.

DICRANACEÆ.

Dicranella.

D. PYGMÆA *Card.*, sp. nova.

Dioica, humillima, lutescenti-viridis, 5–6 millim. alta. Folia erecta vel leniter subsecunda, anguste triangulari-lanceolata, sensim in acumen canaliculatum, crassiusculum, integrum, acutum vel obtusulum producta, 0·9–1·35 millim. longa, 0·18–0·25 lata, marginibus superne inflexis, cæterum planis et ubique integerrimis, costa valida, lutescente, bene limitata, quartam vel tertiam partem basis occupante, continua vel subexcurrente, cellulis oblongis, rectangulis et linearibus, parietibus firmis, incrassatis. Folia perichætialia majora, anguste oblongo-lanceolata, laxius reticulata. Capsula in pedicello pallido, circa 2 millim. longo, siccitate apice leniter dextrorsum torto minima, erecta vel suberecta, sicca ovata, madida subglobosa, aperta late truncata, circa 0·5 millim. longa, 0·3–0·4 lata, operculo longirostri capsulæ æquilongo. Annulus duplex et triplex. Peristomium rudimentarium, dentibus minimis, rubellis, irregularibus, annulo vix æquilongis et quidem brevioribus. Planta mascula ignota.

Très voisine du *D. minuta* (Hpe.) Broth., de Madagascar, cette espèce en diffère cependant par ses feuilles plus longues et plus étroitement acuminées. Elle était mélangée à l'espéce suivante.

D. ASCENSIONICA *Mitt.*, in Mellis, *St Helena*, p. 357.

Par son pédicelle fortement flexueux et courbé, cette espèce se rapproche des *Campylopodium*, mais les feuilles sont moins brusquement dilatées à la base que celles de ce genre. M. Brotherus a fait d'ailleurs observer avec raison que le genre *Campylopodium* est très faiblement caractérisé, et qu'il serait peut-être préférable de le considérer comme un sous-genre de *Dicranella* (*Musci*, in *Pflanzenfamil.*, p. 312).

Campylopus.

C. SMARAGDINUS (*Brid.*) *Jaeg.*, *Ad.*, i. p. 136.

Il y a, dans l'herbier du Museum de Paris, deux échantillons de cette espèce. L'un, provenant de l'herbier Thuret, récolté par Lesson en 1829, et étiqueté par Bescherelle, est du *C. smaragdinus* pur. L'autre, provenant de l'herbier Brongniart, est un échantillon de la plante originale récoltée par Dumont d'Urville en 1825, et sur laquelle Bridel a établi son *Didymodon smaragdinus* (*Bryol. univ.*, i. p. 819). Cet échantillon était étiqueté primitivement "*Thisanomitrium introflexum*," puis a été rapporté plus tard par Bescherelle au *C. smaragdinus*. Mais, en réalité, il comprend deux espèces : la plus grande partie de la touffe est bien du *C. smaragdinus*, au milieu duquel on trouve des brins d'une espèce à feuilles pilifères, à nervure fortement lamellifère sur le dos, qui est, conformément à la première étiquette, du *C. introflexus* (Hedw.) Mitt., si toutefois, avec Mitten, on réunit au *Dicranum introflexum* d'Hedwig le *C. polytrichoides* De Not., mais à laquelle il faudrait attribuer ce dernier nom, si l'on réserve celui de *C. introflexus* aux formes australes à poil réfléchi ou plus ou moins étalé.

L'échantillon des récoltes de M. Rudmose Brown qui m'a été communiqué par l'Herbier royal de Kew, appartient au *C. smaragdinus* ; mais il est fort possible qu'il y avait dans la récolte de M. Brown le même mélange que dans celle de Dumont d'Urville, car sur la liste qui a été publiée dans *Trans. and Proc. of the Bot. Soc. Edinb.*, vol. xxiii., part ii., on ne trouve cité que *C. introflexus*, bien que les deux espèces soient totalement différentes.

Pottiaceæ.

Hyophila.

H. Ascensionis *Card.*, sp. nova.

"*Barbula cf. leucochlora* C. Müll.," Wright, *loc. cit.*

Cespites fusco-virides. Caulis erectus, apicem versus dichotome vel fastigiato-ramosus, 12–15 millim. altus. Folia siccitate crispata, madore erecto-patentia, oblongo-lingulata, brevissime acuminata vel subapiculata, in singula innovatione annua ascendendo majora, media et superiora 1·75–2·25 millim. longa, 0·5–0·7 lata, marginibus plus minus inflexis, superne irregulariter crenato-subdenticulatis, costa rufa, valida, 100–120 μ basi crassa, continua vel brevissime excedente, cellulis majusculis, subrotundatis vel subquadratis, papillosis, chlorophyllosis, parietibus lutescentibus incrassatis, interioribus rectangulis, pellucidis. Cætera desiderantur.

Cette espèce rappelle assez, par son aspect général, le *H. crenulatula*, C. Müll., du Cameroun, mais s'en distingue aisément par ses feuilles plus courtes, formés de cellules 3 à 4 fois plus grandes.

Bartramiaceæ.

Philonotis.

Ph. pergracilis *Card.*, sp. nova.

"*Bartramia cf. subolescens* C. Müll.," Wright, *loc. cit.*

Cespites tenelli, virides, intus dense fusco-tomentosi. Caulis erectus, gracillimus, parcissime ramosus vel subsimplex, 15–25 millim. altus. Folia erecto-patentia, anguste lanceolata, sensim cuspidata, minima, 0·9–1·1 millim. longa, 0·15–0·2 lata, marginibus plerumque e basi longe et anguste revolutis, apicem versus planis, ubique simpliciter serrulatis, costa basi 30–40 μ crassa, dorso scabra, in cuspidem denticulatam, validiusculam excedente, cellulis angustis, linearibus, parietibus transversis prominentibus, inferioribus laxioribus, rectangulis quadratisve. Cætera ignota.

Bien distinct du *Ph. subolescens* (C. Müll.) Par. par ses tiges plus élancées, ses feuilles beaucoup plus longues, révolutées aux bords, et son tissu plus serré et plus chlorophylleux. Je ne connais pas le *Ph. penicillata* Wright, qui est également particulier à l'Ascension, mais il est probable que ce n'est pas la même chose que la Mousse que je viens de décrire, puisque M. Wright, qui a vu celle-ci, n'y a pas reconnu son espèce, et l'a rapprochée de préférence du *Ph. subolescens.*

EXPLICATION DES PLANCHES.

Planche I.

Fig. 1. *Sphagnum Scotiæ.*—*a*, feuille caulinaire ; × 13. *b*, *c*, feuilles d'un rameau divergent ; × 13. *d*, tissu dans le haut d'une feuille caulinaire ; × 270. *e*, tissu dans la moitié supérieure d'une feuille raméale, vu par la face dorsale ; × 270. *f*, portion d'une section transversale vers le milieu d'une feuille raméale ; × 270.

Fig. 2. *Trematodon intermixtus.*—*a*, plantes, gr. nat. *b*, *c*, feuilles ; × 13. *d*, *e*, capsules déoperculées ; × 13. *f*, fragment du péristome et spores ; × 138.

Fig. 3. *Campylopus alvarezianus.*—*a*, plante, gr. nat. *b*, *c*, *d*, feuilles ; × 13. *e*, tissu basilaire d'une feuille ; × 138. *f*, tissu vers le milieu d'une feuille ; × 270. *g*, sommet d'une feuille ; × 138. *h*, partie d'une coupe transversale de la nervure, dans la moitié supérieure ; × 270.

Fig. 4. *Macromitrium antarcticum.*—*a*, plante, gr. nat. *b*, *c*, *d*, *e*, feuilles ; × 26. *f*, tissu basilaire d'une feuille ; × 270. *g*, tissu vers le milieu d'une feuille ; × 270. *h*, sommet d'une feuille ; × 270. *i*, capsule jeune et encore operculée ; × 13. *j*, capsule mûre, déoperculée, à l'état sec ; × 13. *k*, fragment du péristome ; × 138. *l*, coiffe ; × 13.

Fig. 5. *Bryum tenellicaule.*—*a*, plante, gr. nat. *b*, extrémité d'une tige ; × 13. *c*, *d*, *e*, feuilles ; × 26. *f*, tissu basilaire d'une feuille ; × 138. *g*, sommet d'une feuille ; × 138.

Fig. 6. *Bryum subulinerve.*—*a*, *b*, plantes, gr. nat. *c*, extrémité d'une tige ; × 13. *d*, *e*, *f*, *g*, feuilles ; × 26. *h*, tissu basilaire d'une feuille ; × 138. *i*, sommet d'une feuille ; × 138.

Planche II.

Fig. 7. *Bartramia stenobasis.*—*a*, plante, gr. nat. ; *b*, *c*, feuilles ; × 13. *d*, tissu de la partie supérieure de la base d'une feuille ; × 138. *e*, tissu marginal vers le milieu d'une feuille ; × 138. *f*, sommet d'une feuille ; × 138.

Fig. 8. *Thuidium alvarezianum.*—*a*, *b*, plantes, gr. nat. *c*, extrémité d'une tige ; × 13. *d*, *e*, *f*, feuilles caulinaires ; × 32. *g*, *h*, *i*, feuilles d'un rameau primaire ; × 32. *j*, *k*, *l*, feuilles d'un rameau secondaire ; × 32. *m*, tissu marginal vers le milieu d'une feuille caulinaire ; × 270. *n*, sommet d'une feuille caulinaire ; × 270. *o*, paraphylles ; × 270.

Fig. 9. *Isopterygium Brownii.*—*a*, *b*, *c*, plantes, gr. nat. *d*, extrémité d'une tige ; × 13. *e*, *f*, *g*, *h*, feuilles ; × 26. *i*, tissu basilaire d'une feuille ; × 270. *j*, sommet d'une feuille ; × 270.

Fig. 10. *Isopterygium ambiguum*—*a*, plante, gr. nat. *b*, extrémité d'une tige ; × 13. *c*, *d*, *e*, *f*, *g*, feuilles ; × 13. *h*, tissu basilaire d'une feuille ; × 270. *i*, sommet d'une feuille ; × 270.

Fig. 11. *Brachythecium pallidoflavens.* —*a*, plante, gr. nat. *b*, extrémité d'un rameau ; × 13. *c*, *d*, *e*, feuilles ; × 26. *f*, tissu basilaire d'une feuille ; × 270. *g*, tissu marginal dans la moitié supérieure d'une feuille ; × 270. *h*, sommet d'une feuille ; × 270.

Planche III.

Fig. 12. *Rhynchostegium isopterygioides.*—*a*, plante, gr. nat. *b*, extrémité d'un rameau ; × 13. *c*, *d*, *e*, *f*, *g*, feuilles ; × 13. *h*, tissu basilaire d'une feuille ; × 138. *i*, tissu marginal vers le milieu d'une feuille ; × 138. *j*, sommet d'une feuille ; × 138. *k*, feuille périchétiale intime ; × 13.

Fig. 13. *Dicranella pygmæa.*—*a*, *b*, plantes ; × 3. *c*, *d*, *e*, feuilles ; × 26. *f*, tissu basilaire d'une feuille ; × 138. *g*, sommet d'une feuille ; × 138. *h*, feuille périchétiale ; × 26. *i*, *j*, capsules operculées, à l'état sec ; × 26. *k*, capsule mûre, ouverte, à l'état humide ; × 26. *l*, fragment du péristome et de l'anneau ; × 138. *m*, feuille de *D. minuta* (Hpe.) Broth. ; × 26.

Fig. 14. *Hyophila Ascensionis.*—*a*, *b*, plantes, gr. nat. *c*, extrémité d'une tige ; 13. *d*, *e*, *f*, *g*, *h*, feuilles ; × 13. *i*, tissu basilaire d'une feuille ; × 138. *j*, tissu dans la partie moyenne d'une feuille ; × 270. *k*, sommet d'une feuille ; × 138.

Fig. 15. *Philonotis pergracilis.*—*a*, plante, gr. nat. *b*, *c*, extrémité de deux tiges ; × 13. *d*, *e*, *f*, feuilles ; × 32. *g*, tissu basilaire d'une feuille ; × 138. *h*, tissu marginal d'une feuille, vers le milieu ; × 270. *i*, sommet d'une feuille ; × 138.

JULES CARDOT: LES MOUSSES DE L'EXPÉDITION NATIONALE ANTARCTIQUE ÉCOSSAISE.– PLANCHE I.

Fig. 2.

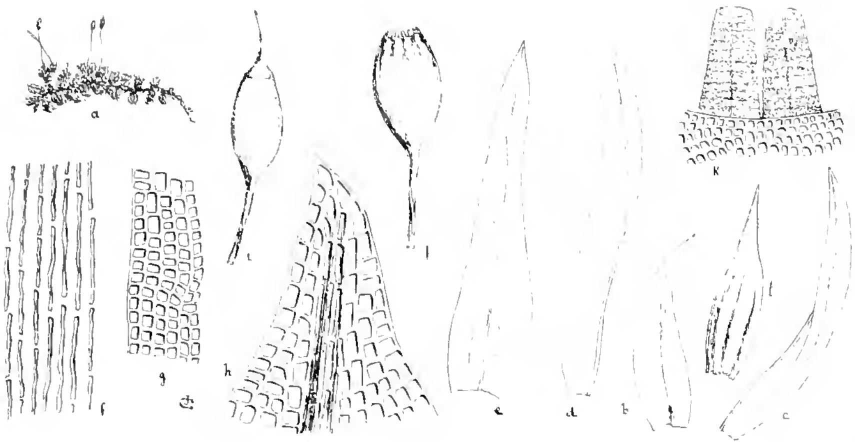


Fig. 4.

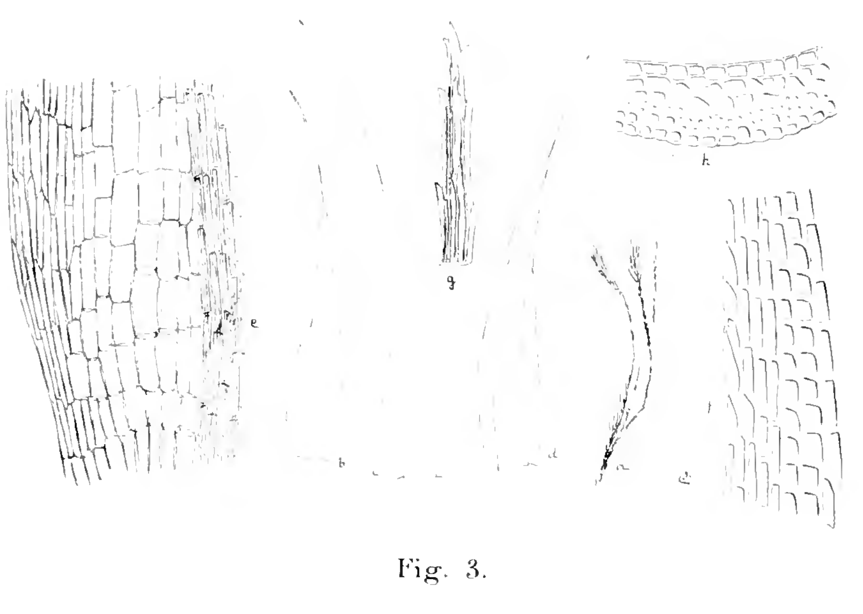


Fig. 3.

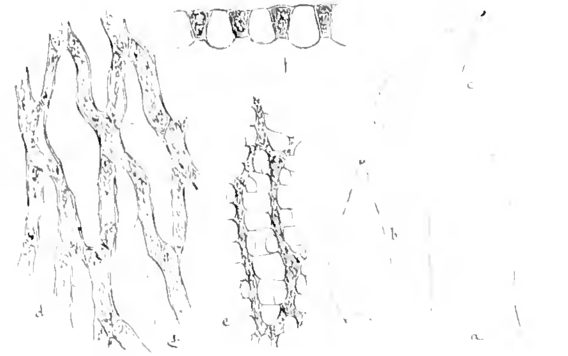


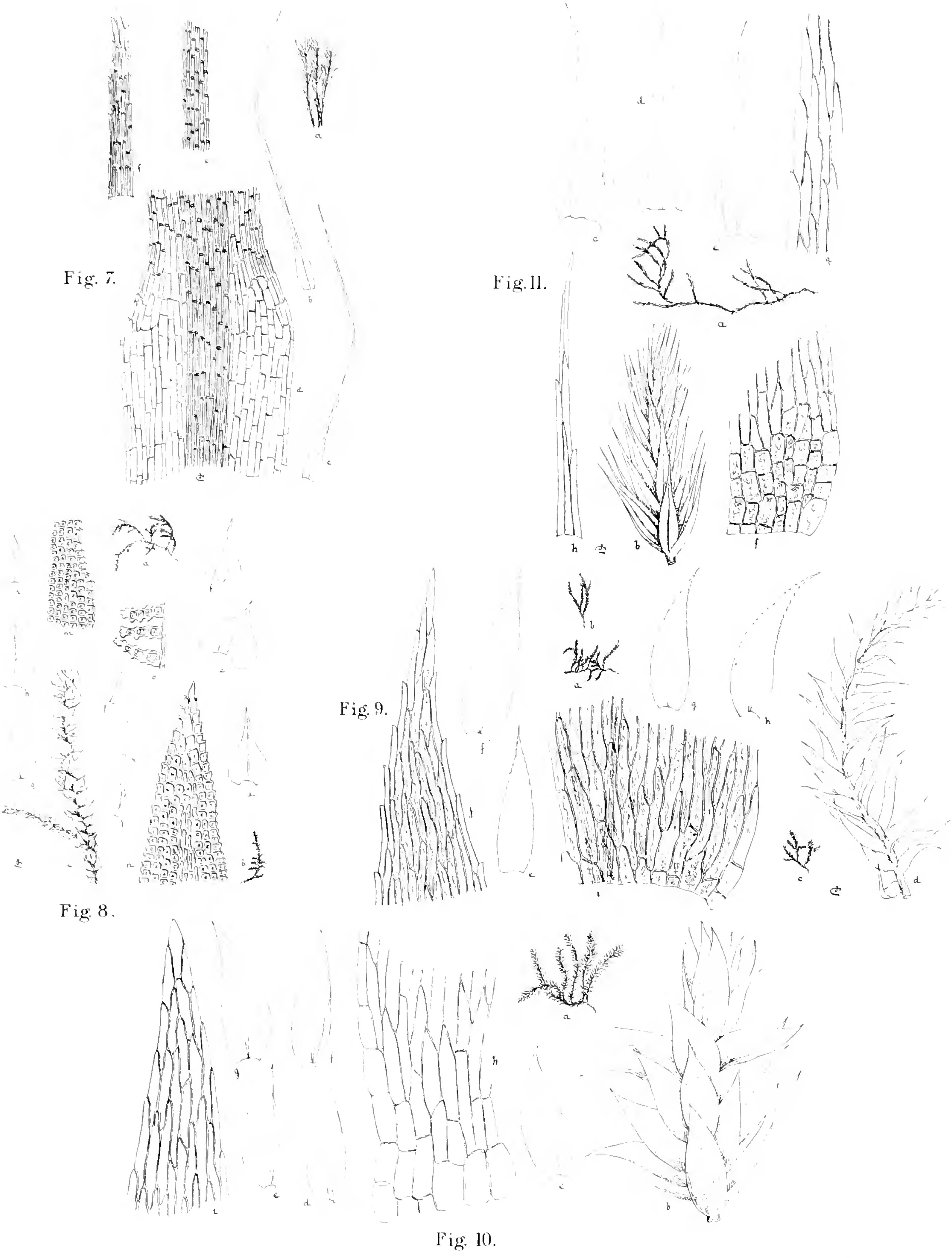
Fig. 1.

Fig. 5.

Fig. 6.

M'Farlane & Erskine, Lith., Edin.

JULES CARDOT : LES MOUSSES DE L'EXPÉDITION NATIONALE ANTARCTIQUE ECOSSAISE. PLANCHE II.



M'Farlane & Erskine, Lith., Edin.

Jules Cardot: Les Mousses de l'Expédition nationale antarctique écossaise — Planche III.

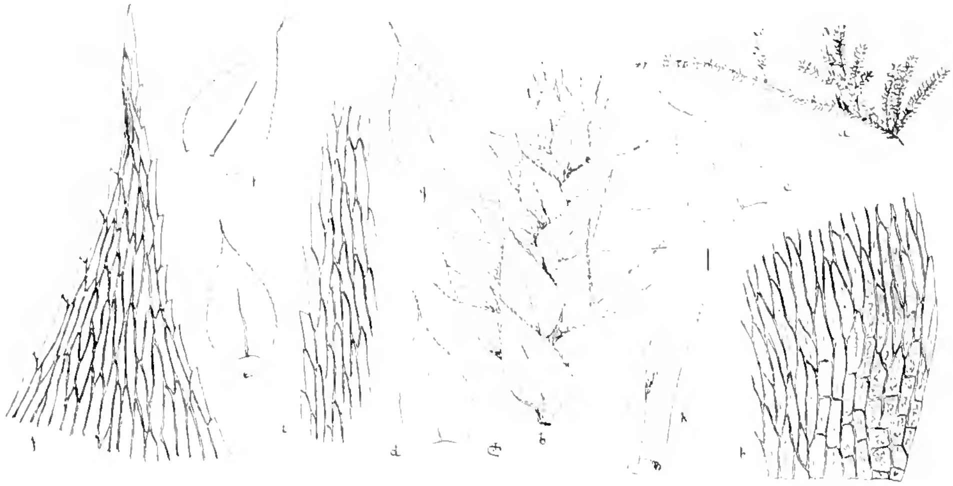


Fig. 12.

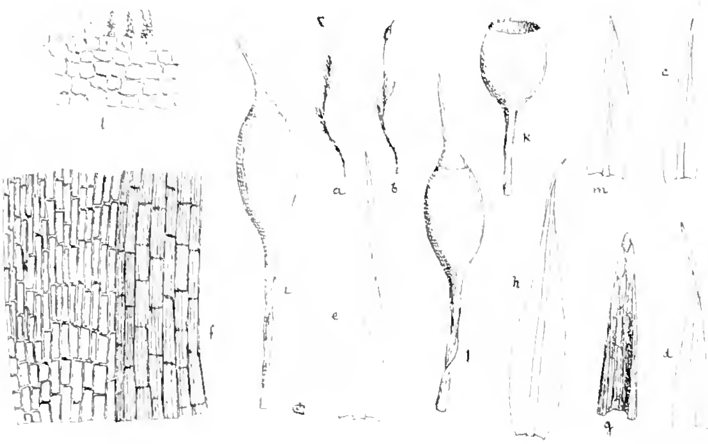


Fig. 13.

Fig. 15.

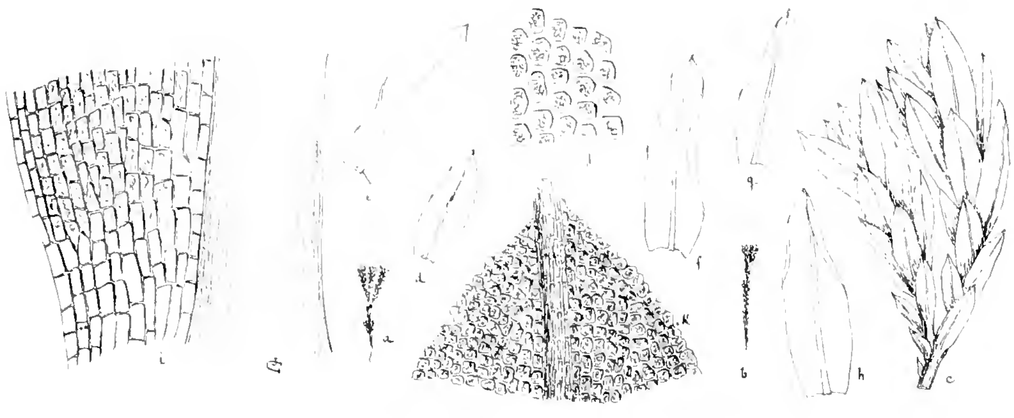


Fig. 14.

MFarlane & Erskine, Lith., Edin.

VI.—MARINE ALGÆ OF THE SCOTTISH NATIONAL ANTARCTIC EXPEDITION.

VI.—MARINE ALGÆ OF THE SCOTTISH NATIONAL ANTARCTIC EXPEDITION.[1]

By A. Gepp, M.A., British Museum, and Mrs E. S. Gepp.

(*With Two Plates.*)

The following is a combined list of the marine algæ brought back by the Scottish National Antarctic Expedition, and communicated to us by Dr R. N. Rudmose Brown. They were gathered partly in the cold southern waters of the South Orkneys, and partly in tropical and subtropical waters off the coast of Brazil, at St Paul Rocks and St Vincent, Cape Verde Islands. The South Orkneys lie about 45° W. long. and 61° S. lat.; they are therefore situated outside the Antarctic circle, and far to the south-east of Cape Horn. No algæ had previously been recorded from these islands, so far as we are aware, the nearest being from South Georgia, and described by P. F. Reinsch in Neumayer's *Internationale Polarforschung*, 1882–83: *Die Deutschen Expeditionen*, Bd. ii. (1890), pp. 366–449.

Chlorophyceæ.

1. Monostroma endiviæfolium, *A. and E. S. Gepp* in *Journ. of Bot.*, xliii., 1905, p. 105, tab. 470, figs. 1–5.

Thallus sessilis, subnigrescenti-viridis, membranaceus, callo vix ullo, mox expansus, maxime et dense crispato-undulatus, haud laceratus, parvus, 2–4 cm. altus et latus, 60–67 μ crassus; cellulis geminis vel quaternis, in sectione thalli transversali verticaliter rectangularibus, angulis rotundatis; cellulis basalibus longissime caudatis. (Figs. 1–5.)

Habitat.—Shore pools and exposed at low tide, February 4, 1903, Saddle Island, South Orkneys.

The nearest allies of *M. endiviæfolium* are *M. Blyttii*, Wittr., and *M. splendens*, Wittr. From *M. Blytii* it differs in having an excessively crisped, not lacerate, frond, and in being smaller. Also the cells of *M. endiviæfolium* seen in surface view are more widely separated than those of *M. Blyttii*. From *M. splendens* it differs in colour,

[1] The majority of the notes that follow, and of the figures that illustrate them, were published previously in the following papers:—"Antarctic Algæ" (in *Journ. of Bot.*, xliii., 1905, pp. 105–09, tab. 470); "Atlantic Algæ of the *Scotia*" (*tom. cit.*, pp. 109, 110); "Leptosarca: a correction" (*tom. cit.*, p. 162); "More Antarctic Algæ" (*tom. cit.*, pp. 193–196, tab. 472); "A New Species of Lessonia" (*op. cit.*, xliv., 1906, pp. 425, 426); "Marine Algæ" (in *National Antarctic Expedition*, iii., British Museum (Natural History), 1907, 15 pp., 4 plates).

in not being coriaceous, in its smaller size, thicker thallus, and longer narrower cells as seen in section.

Reinsch, in his list of South Georgian Algæ (p. 420), quoted above, describes a new variety, *macrogyna* of *Ulva Lactuca.* This plant is, he says, composed of a single layer of cells, those at the base being very longly caudate. The former of these characters would place Reinsch's plant in *Monostroma* rather than in *Ulva.* The habit of var. *macrogyna* is, however, quite different from that of *M. endiviæfolium.* It is broad, large and flat like *Ulva Lactuca,* and the size of the cells is much smaller than that of our plant. If we regard var. *macrogyna* as a *Monostroma,* these two plants are the only Antarctic species of the genus known to us.

2. ULVA LACTUCA, *L.* St Vincent, December 1, 1902.
Geographical Distribution.—Cosmopolitan.

3. CHÆTOMORPHA, sp. A fragment. Between Rio and Bahia, off the coast of Brazil, December 20, 1902, lat. 18° 24′ S., long. 37° 58′ W.

4. MICRODICTYON UMBILICATUM, *Zan.* Off Brazil, same locality as No. 3.
Geographical Distribution.—Mediterranean, Warm Atlantic, Warm Pacific, Indian Ocean, Red Sea.

5. BRYOPSIS PENNATA, *Lam.* St Paul Rocks, December 10, 1902. Surface.
Geographical Distribution.—Warm Atlantic, Indian Ocean.

6. CAULERPA RACEMOSA, *J. Ag.*, var. LÆTEVIRENS, forma CYLINDRACEA, *Web. v. B.* St Paul Rocks, December 10, 1902, lat. 0° 58′ N., long. 29° 20′ W. Shore.
Geographical Distribution.—Warm Atlantic, Indian Ocean, Australia.
Var. UVIFERA, *Web. v. B.* Off Brazil, same locality as No. 3.
Geographical Distribution.—West Indies, Indian Ocean, Friendly Islands.

7. C. MURRAYI, *Web. v. B.* Off Brazil, same locality as No. 3.
Geographical Distribution.—Victoria Banks, Brazil.

8. CODIUM TOMENTOSUM, *Stackh.* Off Brazil, same locality as No. 3.
Geographical Distribution.—Mediterranean, North Atlantic, Cape of Good Hope, Indian Ocean, Red Sea, North Pacific, Australia.

PHÆOPHYCEÆ.

9. SARGASSUM VULGARE, *Ag.* Off Brazil, same locality as No. 3. St Vincent, shore, December 1, 1902.
Geographical Distribution.—Warm Atlantic.

The first record consists of fragments of plants with few and widely scattered leaves. The second specimen has many and crowded leaves, which are smaller than those of the Brazil specimens. The St Vincent plants agree exactly with specimens collected by the *Challenger* from the same locality, and preserved in the herbaria of the British Museum and the Royal Gardens, Kew.

10. GYMNOSORUS VARIEGATUS, *J. Ag.* Two specimens without fruit. Off Brazil, same locality as No. 3.

Geographical Distribution.—Warm Atlantic, Warm Pacific, Red Sea.

11. STYPOPODIUM LOBATUM, *Kütz.* Five specimens without fruit. Off Brazil, same locality as No. 3.

Geographical Distribution.—Canaries, West Indies, Chatham Island.

12. DICTYOTA DICHOTOMA, *Lam.* Off Brazil, same locality as No. 3.

These plants show a variation from the ordinary type, inasmuch as the two branches of the final dichotomy take on the narrow form characteristic of f. *intricata.* Below this final dichotomy the plants are quite typical, and the change is a sudden one. Mr Lloyd Williams has been so kind as to give us his opinion on one of the specimens, saying that this development is probably the result of unfavourable environment at a late stage of growth. He adds that he is able to bring about such a change artificially in laboratory cultures. It is recorded as having been taken at a depth of 36 fathoms—a very deep habitat for a *Dictyota.* But possibly it was caught floating free in the water; and possibly it is a starvation-form. When an alga is fixed, it thrives in the food-bearing currents which sweep past it; but if it should break off and float away in such a current, it would soon exhaust the food in its neighbourhood, and would then be in risk of starvation. And if carried down to an undue depth, it would pass out of the zone of optimum conditions of light, CO_2, etc.

13. PHYLLOGIGAS SIMULANS, comb. nov.

Syn. Lessonia grandifolia, *A. and E. S. Gepp* pro parte in *Journ. of Bot.*, xliii., 1905, p. 105, tab. 470, fig. 6. Lessonia simulans, *A. and E. S. Gepp* in *Journ. of Bot.*, xliv., 1905, p. 425; *National Antarctic Expedition*, iii., British Museum (Natural History), 1907, "Marine Algæ," pp. 5–7, pl. ii., fig. 10. Phyllogigas grandifolia, *Skottsberg* pro parte in *Wissen. Ergebn. Schwed. Südpolar-Exp.*, Bd. iv., Lief. 6, 1907, pp. 63–69.

Planta incompleta. Frons laminarioidea ut in *P. grandifolia*, stipite complanato ancipite suffulta, simplex, lanceolato-linearis, longa, lata (12·5 cm. plusve), marginibus integerrimis. Laminæ substantia pergamentacea vel coriacea, e stratis tribus composita; cellulis corticalibus monostromaticis quadratis granuloso-obscuris; subcorticalibus oblongis parenchymaticis in circa 6–7 series dispositis; medullaribus congestis elongatis angustis strictis 9–10-seriatis tubulos perpaucos subinfundibuliformes vaginâ e cellulis parvulis compositâ vestitos foventibus. Cætera desunt. (Figs. 6, 7.)

Habitat.—Scotia Bay, South Orkneys, near surface, April 1904, *R. N. Rudmose Brown.*

The following details of the minute structure were published in the Report of the *National Antarctic Expedition* (*loc. cit.*):—

The *lamina* has a monostromatic cortex, or outer layer, composed of quadratic thin-walled cells with granular contents. Beneath this is a subcortical tissue consisting of about six layers of larger cells, rounded or oblong, lengthened parallel to the axis of the frond. And interior to this is the characteristic medulla, composed of some nine or ten rows of closely juxtaposed, narrow, elongated, and comparatively thick-walled cells, with a few ensheathed trumpet-hyphæ scattered among them. The medullary cells are sometimes filled with a pale-brown mucilage, and their limits are then barely distinguishable. Compare fig. 6 and its description.

In the *stipes* the medulla is the main tissue, and consists of a dense, pale-brown mass of hyphæ, chiefly longitudinal (fig. 7) and straight, but here and there mingled with interwoven hyphæ. Scattered in the medulla are a very few trumpet-hyphæ, some with and some without a sheath of very small cells. The outer cortex lies beneath a distinct superficial cuticle, and consists of three or four rows of small quadrate cells arranged in radiating lines, which, passing inwards, gradually change into a pluri-stromatic subcortex of large round and oblong cells, which in turn merges into the medulla.

The structure of the *holdfasts*, or organs of attachment, rather resembles that of the stipes, but the strata are less definitely marked. There is a dense medullary mass of hyphæ, without any trumpet-hyphæ. The outer cortex is composed of small, dense-coloured quadrate cells which, traced radially inwards, change gradually into larger and larger thin-walled subcortical cells, which in turn undergo transition into the medulla.

As regards the systematic position of the plant, we had no doubt in our minds at first that it was conspecific with the type of our *Lessonia grandifolia* from Cape Adare. For the *Scotia* specimens, though fragmentary, suggested a striking external resemblance to the type. But later, when we had made a more careful comparison of the microscopic structure, we found ourselves compelled to separate the *Scotia* plant off as a proper species—*Lessonia simulans*.

The most obvious difference between *L. simulans* and *L. grandifolia* is found in the medulla of the lamina. In *L. simulans* the medulla is a very pale-brown tissue of close-set elongated cells, with very few ensheathed trumpet-hyphæ among them; whereas in *L. grandifolia* the medulla is colourless and composed of hyphæ mostly longitudinal, laxly juxtaposed, separated from one another by one or two times their diameter, and interspersed with numerous ensheathed trumpet-hyphæ disposed in a wide median band. Another point of difference is found in the cortex, which in *L. simulans* is monostromatic, and composed of quadrate cells with granular contents. In *L. grandifolia* the cortex is composed of short vertical crowded rows of small brown cells.

But whether *L. simulans* differs essentially from *L. grandifolia* in habit or external characters, we are unable to say; for the material of the former was incomplete.

Dr C. Skottsberg (*loc. cit.*) criticised our separation of the two species; and in founding his new genus *Phyllogigas* he reunited them in its single species. His criticism provokes a wish to reinvestigate the *Scotia* material. Unfortunately, that material has long since passed out of our hands—and indeed out of our memory. And at the time of writing this note we are far removed from access to slides, microscope, herbarium, books. But from what we can remember of the specimens, and from what we have written about them, we feel that Dr Skottsberg has failed to appreciate the structural differences which in our opinion separate the species. *L. simulans* may well be a species of *Phyllogigas*; and we have now placed it therein as a second species, that is, distinct from *P. grandifolia.*

In treating of *P. grandifolia*, Dr Skottsberg based his detailed description and his figures of the anatomy upon his own material gathered in South Georgia and Graham Land. But, as far as we can understand them, they appear to us to approach much more nearly to the structure of the type of *P. simulans* from the South Orkneys than to that of *P. grandifolia* from Cape Adare in Victoria Land—a conclusion which would be in agreement with the widely separated distribution of the two species in the Antarctic region. It should be added that Dr Skottsberg, when writing his paper, had not seen our fuller account and figures of these types published in the Report of the *National Antarctic Expedition.* For though our paper was already in type a month or two before we had the pleasure of making Dr Skottsberg's acquaintance, yet it was not actually published until a few weeks after his paper appeared.

14. Adenocystis Lessonii, *Hook. and Harv.* MacDougall Bay, South Orkneys, November 1903.

Geographical Distribution.—Cape Horn, Falklands, Auckland and Campbell Islands, Cockburn Island, Wandel Island, Kerguelen, Tasmania, and New Zealand.

15. Desmarestia Rossii, *Hook. and Harv.* Scotia Bay, South Orkneys, 1–3 fathoms, March 1, 1903.

Geographical Distribution.—Cape Horn, Falklands.

It is surprising that the *Scotia* collections contain no example of the plant called *D. media* in the *Flora Antarctica*, part ii. (1847), p. 466. It is a common species in the south polar region, and well represented in the *Discovery* collections; but it is not—as Harvey supposed—identical with the northern *D. media*, Grev. (*Sporochnus medius*, C. Ag.). We have been compelled to rename the southern species *D. Harveyana.* Our reasons for this have been given in the Report of the *National Antarctic Expedition*, iii. p. 7.

Florideæ.

16. Wildemania laciniata, *De Toni* (=*Porphyra laciniata*, Ag.). Buchan Bay, South Orkneys, March 25, 1903; Scotia Bay, South Orkneys.

Geographical Distribution.—Mediterranean, North Atlantic, South Georgia.

17. Gelidium corneum, *Lam.* Two specimens without fruit. Also two fragments attached to *Sargassum vulgare.* St Vincent, December 1, 1902. Shore.

Geographical Distribution.—Cosmopolitan.

18. Callophyllis variegata, *Kütz.* ? Scotia Bay, South Orkneys, July 1903.

Geographical Distribution. — S.-E. Pacific, New Guinea, Kerguelen, Auckland Islands, and Straits of Magellan.

This is a sterile and incomplete plant, and consequently we are unable to determine it with certainty. Its structure, as seen in a transverse section of an older part of the frond, much resembles that of *Callophyllis variegata.* The thallus is composed of two strata, the interior consisting of large, thick-walled cells, separated from one another by smaller flexuose tubular cells, and passing into a cortex of small round cells, laxly and irregularly arranged in a cartilaginous matrix. The cortex is here and there invaded by a green endophyte, probably *Chlorochytrium* (fig. 8). In younger parts of the frond the cortex is monostromatic, and the interior has a fibrous appearance, owing to the collapse of the cells. As to the habit of the plant, the base is absent, and the fragment of thallus which we have seen is more or less palmately lobate and irregularly proliferous, membranaceous in texture, and coccineo-rosaceous in colour. The specimen is 7 cm. high and 9 cm. wide.

C. variegata is of common occurrence about Cape Horn and the Falkland Islands, and our plant may be one of its broader forms.

19. Acanthococcus spinuliger, *Hook. and Harv.* Scotia Bay, South Orkneys, 9–10 fathoms, May 1903; December 1903.

Geographical Distribution.—Cape Horn, Falklands, Punta Arenas.

20. Gracilaria simplex, *A. and E. S. Gepp* in *Journ. of Bot.*, xliii., 1905, p. 195, tab. 472, fig. 4; *National Antarctic Expedition*, iii., British Museum (Natural History), 1907, Marine Algæ, pp. 9, 10.

Syn. Leptosarca simplex, *A. and E. S. Gepp* in *Journ. of Bot.*, xliii., 1905, pp. 108, 162, tab. 470, figs. 10, 11.

Frondes plures (8–10) e callo minuto ortæ simplices oblongæ vel lato-cuneatæ planæ membranaceæ, 10–15 cm. longæ (apice destructo), 3–8 cm. latæ, c. 230 μ crassæ, inferne in stipitem plus minusve sensim angustatum, 1–3 cm. longum attenuatæ, stratis duobus contextæ, cellulis interioribus rotundato-angulatis magnis 2–3-seriatis pachydermis (frondis sterilis majoribus maxime leptodermis collabentibus submonostromaticis); cellulis corticalibus filamenta ramosa verticalia efficientibus, tetrasporangia magna cruciatim divisa foventibus (frondis sterilis majoribus monostromaticis). (Figs. 9–11.)

Habitat.—South Orkneys, shores of Uruguay Cove, March 26, 1903; also Scotia Bay, June 1903. This species was also collected by the British, French, and Swedish Antarctic Expeditions.

When first studying this species we had but a few sterile fronds before us; and, noting the extreme thinness of frond, the large celled monostromatic cortex, and the thin-walled great interior cells (collapsing irrevocably when dry), we felt that we were dealing with a new genus allied to *Gracilaria*, and we gave it the name of *Leptosarca*. Subsequently we received from Dr Rudmose Brown a more complete plant, gathered in the South Orkneys, which with a few other algæ had been overlooked in the *Scotia*, until that gallant ship was cleared out previous to being sold. This fine specimen bore ten fronds, some of them sterile and having the structure of *Leptosarca*, and others tetrasporiferous—with large cruciate tetraspores, thicker-walled internal cells, and a cortex of short chains of cells arranged perpendicularly to the surface of the frond. Upon finding these characters in the sporangiferous fronds, we thought it advisable to transfer the species to *Gracilaria*, even though the conclusive evidence of the cystocarps is still lacking. The finest examples of this species that we have seen were shown to us by Dr Skottsberg, who collected them during the Swedish South Polar Expedition.

In certain parts of the frond of *G. simplex* we noticed small filaments creeping round the cell-walls. Reinsch (*loc. cit.*, p. 413, tab. xv. figs. 11–13) records two species of *Entonema* from South Georgia, endophytic in other algæ; but our plant does not agree with these, nor indeed with any other species of the genus. We have only the vegetative filaments of our endophyte, and we hesitate, therefore, to give any definite opinion on it. Since, however, the algæ from South Orkneys are few and interesting, it is worth while recording it, as it may occur among other Antarctic collections.

21. EPYMENIA, sp. Scotia Bay, South Orkneys, 9–10 fathoms, May 1903.

Two specimens without fruit. They resemble *E. obtusa* in general habit and structure, but they lack the midrib in the base of the flabellate branches. The length of the midrib seems, however, to be a variable character in *E. obtusa*.

22. PLOCAMIUM HOOKERI, *Harv.* Scotia Bay, South Orkneys, 9–10 fathoms, August 29, 1903; April 1903; May 1903.

The last specimen is so covered with diatoms as to be unrecognisable until it is cleaned.

Geographical Distribution.—Kerguelen, Heard Island, South Georgia.

23. P. COCCINEUM, *Lyngb.* Scotia Bay, South Orkneys, December 1903; 9–10 fathoms, May 1903.

Geographical Distribution.—Cosmopolitan.

24. HYDROLAPATHUM STEPHANOCARPUM, *A. and E. S. Gepp* in *Journ. of Bot.*, xliii., 1905, p. 195, tab. 472, figs. 5–7.

Frons fruticulosa 15–30 cm. alta irregulariter dichotoma 3–4 mm. lata valde costata alata, ala pinnativenia sæpe destructa, prolificationes numerosas lanceolato-lineares costatas pinnativenias, venis oppositis conspicuis, monostromaticas usque ad 32 mm. longas et 4 mm. latas, e costis emittens. Cystocarpia adparenter pedicellata, revera in foliolis minutis transformatis e costa emergentibus sessilia, trichomatibus pluribus instructa. (Figs. 12–14.)

Habitat.—Scotia Bay, South Orkneys, July 1903.

This species is most nearly related to *Delesseria sanguinea*, Lam., from which it differs in having the cystocarps not smooth, but more or less clothed with simple tapering appendages, chiefly disposed around the sides, and leaving the top bare. But for this wreath of appendages we should regard the plant as no more than an old narrow-leaved and very proliferous form of *D. sanguinea.*

The question whether or not *H. stephanocarpum* belongs rightly to the genus *Delesseria* depends on the view held of the systematic position of *D. sanguinea* (= *Hydrolapathum sanguineum*, J. Ag.), with which species our plant must stand or fall. Agardh, attaching primary importance to the structure of the *mature* fruit, regarded *Hydrolapathum* as forming a distinct genus in *Rhodymeniaceæ* near *Rhodophyllis*, on account of its composite cystocarp with "nucleoli" separated by radiating columns of sterile threads, and on account of the carpostomium-structure. Schmitz, on the other hand, reunited *Hydrolapathum* with *Delesseria* on account of the similarity of procarpial development, which is a more primitive character than the mature fruit on which Agardh founded his conclusions. If we follow Schmitz and De Toni, our plant would be called *Delesseria stephanocarpa.* Our own inclination is, however, to follow a middle course. Instead of sinking *Hydrolapathum* into *Delesseria*, from which so many less well-marked genera have been quarried, we would maintain *Hydrolapathum* as an independent genus on the score of the structure of its cystocarps and sporophylls; but we would place it in the *Delesserieæ*, and not in *Rhodymeniaceæ*.

25. Pteridium proliferum, *A. and E. S. Gepp* in *Journ. of Bot.*, xliii., 1905, p. 107, tab. 470, figs. 7–9.

Frons fruticulosa, circa 12 cm. alta, alterne dichotoma (sed ramificatio ob prolificationes copiosas obscura); rami complanati, costati, alati, costa inferne conspicua, superne attenuata, omnino sine venis lateralibus; rami ramulique laciniati, a marginibus costaque prolificantes, alterne et irregulariter dichotomi. Ramuli ultimi membranacei, ligulati vel cuneato-ligulati, usque ad apices obsolete et simpliciter costati, irregulariter lacerati vel grosse dentati, prolificantes. Cellulæ paginales homœocystideæ omnes rotundato-angulatæ. Tetrasporangia sine ordine utroque latere costæ phyllorum parvorum disposita, soros nec in unum confluentes, nec ad apicem attinentes formantia. (Figs. 15–17.)

Habitat.—Scotia Bay, South Orkneys, 9–10 fathoms, May 1903.

We should have preferred to style our plant simply *Delesseria prolifera*, using *Delesseria* in the old wide sense. But that genus, as emended by J. G. Agardh, is now so limited in its scope that we are compelled to refer the plant to *Pteridium*, although we regard it and certain other genera latterly split off *Delesseria* as too nearly allied to be worthy of generic rank. In our species the mode of branching is very much masked by the abundant proliferations. It is in habit most like *P. alata* and *P. pleurosporum*, but differs from the former in being much more irregularly branched, and in having no lateral veins. From *P. pleurosporum* it differs in being very proliferous, and in the sori not being confluent over the costa. The sori, in fact, resemble those of *Hypoglossum denticulatum* as figured in Kützing's *Tab. Phyc.*, xvi. tab. 15, 1 (= *Pteridium spinulosum*, J. Ag.). De Toni divides the genus *Pteridium* into three sections, the first of which contains species with a "frons teretiuscula," which our plant has not; the second section has an obsolete costa; and the third shows a difference in the form and disposition of the cortical cells, which cover the costa and the frond, when seen in surface view, besides having lateral veins. Our plant therefore falls into none of these sections. It may be thought that *P. proliferum* approaches more nearly to *Hypoglossum*; but from that genus it differs in being *branched*, as well as proliferous. From *Erythroglossum* it differs in having proliferations emerging from the costa, and in the similarity in form and size of the cortical cells of costa and frond. It differs from Reinsch's *Delesseria condensata* in having a much less strongly marked costa, and in being proliferous.

26. Pteronia pectinata, *Schmitz* (= *Polysiphonia pectinata*, Hook. and Harv.). Scotia Bay, South Orkneys, July and December 1903.

Geographical Distribution.—Cape Horn, Falklands, South Georgia.

Reinsch (*loc. cit.*, p. 374), in his note on this plant, says he believes it had never been figured. But he had overlooked the coloured figure in Harvey's *Nereis Australis*, tab. xxvii., which represents part of the thallus of a specimen from the Falklands collected by Mrs Sulivan, spelt "Sullivan" on the original in Herb., Kew, where there is an original drawing showing the structure, habit, and cystocarp. One of the *Scotia* specimens was growing attached to *Hydrolapathum stephanocarpum*.

27. Ptilota confluens, *Reinsch*. Scotia Bay, South Orkneys, October 1903. Three incomplete plants without fruit.

Geographical Distribution.—South Georgia.

This species is described and figured by Reinsch (*loc. cit.*, p. 376, tab. iii. figs. 5–9). His figure of a portion of the frond, being reduced to one-third its natural size, is not very helpful in determination. The figures of the structure, combined with the clear diagnosis and remarks, are, however, enough to enable us to recognise our plant as *P. confluens*. Reinsch remarks that the axillary cell in his specimen has almost disappeared. In our plant it is still quite clear.

28. Cryptonemia luxurians, *J. Ag.* Off Brazil, same locality as No. 3.

Geographical Distribution.—Brazil, Martinique.

29. Floridea, *A. and E. S. Gepp* in *Journ. of Bot.*, xliii., 1905, p. 193, tab. 472, figs. 1, 2.

Frons cartilaginea plana, 23 cm. lata, irregulariter lacerata et fenestrata lævis, stratis duobus contexta; cellulis interioribus majusculis (35–70 μ long., 15–25 μ lat.) irregularibus rotundato-angulatis vel plus minusve axin versus perpendiculariter elongatis sparsis cartilagine hyalina immersis hic illic filamento tenui inter se conjunctis; cellulis subcorticalibus minoribus paucis rotundatis, corticalibus elongatis angustis (20–25 $\mu \times 4$ μ) congestis monostromaticis; omnibus protoplasmate granuloso instructis. (Figs. 18, 19.)

Habitat.—Scotia Bay, South Orkneys, March 25, 1903.

This specimen consists of a broad, thickish, cartilaginous frond, recalling *Iridæa*, much rent and irregular in outline, about 23 cm. in length and width. No point of attachment is to be distinguished, and the thallus is ragged and slit at the margin and in the body of the frond—something like Kützing's figure of *Iridæa cornea* (*Tab. Phyc.*, xvii. tab. 20). Neither cystocarps nor tetraspores are present. The surface is smooth, and in some parts the cortex has been eroded, but in others it is quite uninjured. In transverse sections the interior of the thallus is seen to be composed of fairly large irregular cells, rotundato-angulate or elongated more or less perpendicularly to the surface, spaced out and embedded in a hyaline cartilaginous matrix. All the cells are lined with a granular protoplasm, and here and there show distinct thin strands of protoplasm from cell to cell. This broad interior tissue forms the greater part of the thallus, and is bordered on either side by a thin band of much smaller round cells, closer together and abutting on the cortex. The cortex is composed of a row of long, narrow, closely-packed vertical cells. There is no medullary stratum of filaments.

In attempting to determine the systematic position of this plant, we have examined innumerable microscopic preparations of various genera without finding any structure resembling that of our plant. The total absence of a filamentous medulla prevents it from being placed in *Kallymenia* or *Euhymenia*, which otherwise it somewhat resembles. We are very much puzzled by Reinsch's *Kallymenia reniformis* f. *carnosa* (*Meeresalgenfl. v. Süd Georgien*, p. 394), the medullary parenchyma of which he describes as a homogeneous tissue of larger cells with wider lumen than in *K. reniformis*, and packed with starchy contents. He gives no figure, and his description is too incomplete to enable us to decide whether, or how far, his plant approaches ours. He states that his plant has a very different structure from typical *K. reniformis*, except for its cortex. Our plant differs from *K. reniformis* in having its cortical cells vertically elongate, and not rotundate; and its interior cells often elongate perpendicularly, and not parallel to the surface of the frond. Though unable to indicate the genus to which this *Scotia* specimen belongs, we record our observations in the hope that fertile material gathered by one of the other Antarctic expeditions may give the clue to its identity.

Since the above was written, it has occurred to us that this specimen might possibly be an aged incrassate plant of *Gracilaria simplex*. But as the material is no longer in our possession, we are unable to put this idea to the test.

DESCRIPTION OF PLATES.

(Figs. 1–6, 8–19 are reproduced from *Journ. of Bot.*; and Fig. 7 from the Report of the *National Antarctic Expedition*—by kind permission of the Editor of the *Journal of Botany* and the Trustees of the British Museum respectively.)

Fig. 1. *Monostroma endiviæfolium.*—Portion of plant, nat. size. Fig. 2. Caudate basal cells, seen in surface view, × 150. Fig. 3. Ditto, seen in longitudinal section, × 150. Fig. 4. Upper part of thallus, transverse section, × 150. Fig. 5. Ditto, surface view: *a*, showing cells in twos and fours shortly after division; and *b*, when they are more evenly distributed, × 150.

Fig. 6. *Phyllogigas simulans.*—Longitudinal section of lamina, showing central strand of hyphæ, with one "trumpet-hypha" in longitudinal, and one in transverse view, × about 150. The cells of the external layer are in reality quadrate, thin-walled, with granular contents, and not, as shown here, rotundate and densely obscured. Fig. 7. Outer part of longitudinal section of stipes, representing the cortex composed of short perpendicular rows of small quadrate cells, which, passing inwards, change gradually into a pluriseriate subcortex of large round and oblong cells, which in turn merge into the medulla; this latter is composed of densely packed straight hyphae; only the external part of the medulla is shown, × 110.

Fig. 8. *Callophyllis variegata?*—Transverse section of thallus, showing endophyte, × 288.

Fig. 9. *Gracilaria simplex.*—Transverse section of fertile frond, showing tetrasporangia, × 288. Fig. 10. Outline of a sterile frond with eroded apex, nat. size. Fig. 11. Transverse section of thallus of same: *a*, taken from margin, showing thick-walled cells; *b*, taken from middle of frond, where the cells have much thinner walls. In *b* may be seen filaments of *Entonema* creeping over the cell-walls, × 150. In fig. 11 the walls of the large interior cells are represented as two to four times as thick as they should be. The largest of the interior cells have a diameter of 200 μ. The cortical cells measure 12–15 μ long by 6–10 μ thick.

Fig. 12. *Hydrolapathum stephanocarpum.*—Portion of plant, nat. size. Fig. 13. Cystocarp, × 30. Fig. 14. Section of cystocarp sessile on sporophyll, × 30.

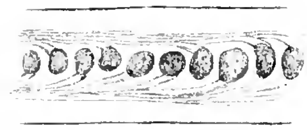
Fig. 15. *Pteridium proliferum.*—Branch showing proliferations from margin and midrib, nat. size. Fig. 16. Tetrasporic branchlet with growing points, and showing, not cortex, but interior tissue, × 30. Fig. 16A. Apex of lobe, surface view, × 150. Fig. 17. Tetrasporangia, surface view, showing their subcortical position, × 350.

Fig. 18. *Floridea.*—Transverse section of thallus, × 44. Fig. 19. Portion of same, showing cortex and interior cells, × 288.

GEPP: MARINE ALGÆ—PLATE I.

1

2.



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5a

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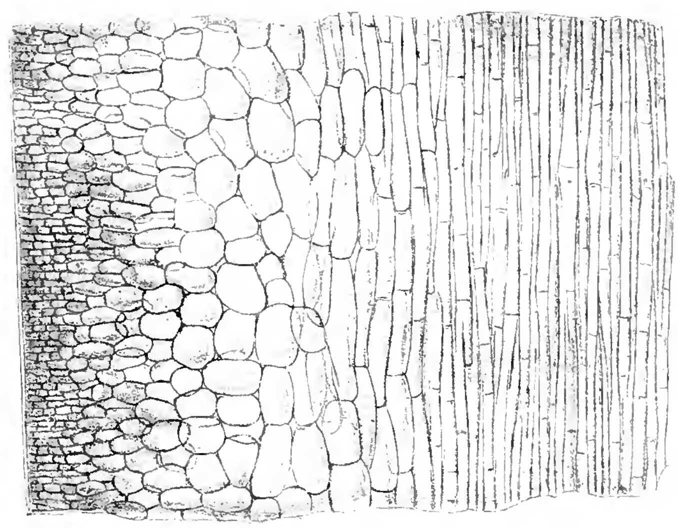

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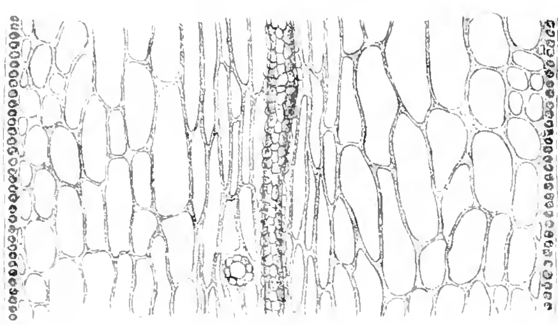

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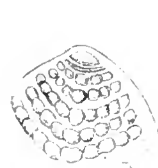

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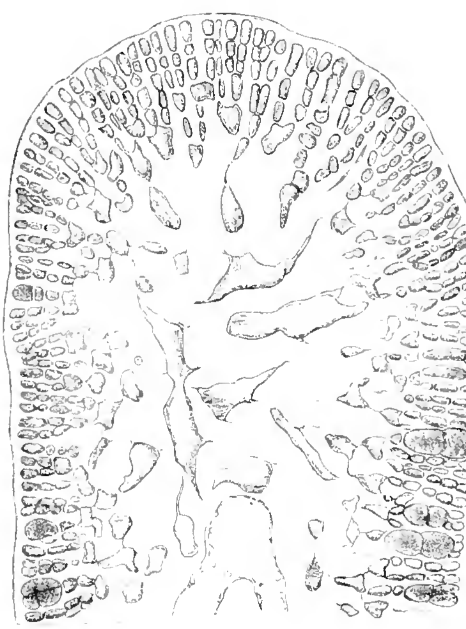

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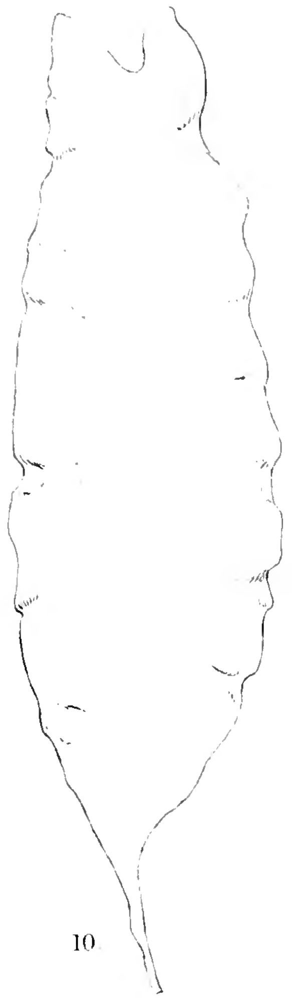
ANTARCTIC ALGÆ.

Gepp: Marine Algæ—Plate II.



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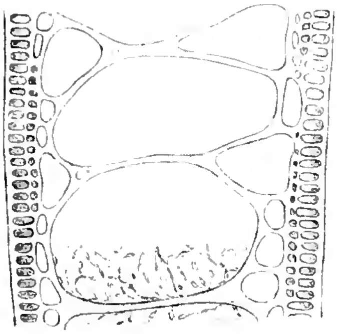

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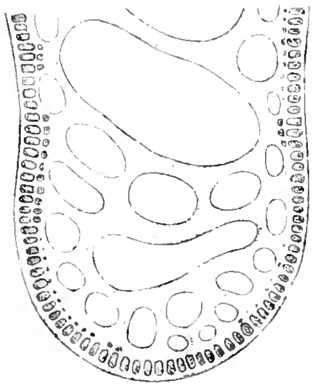

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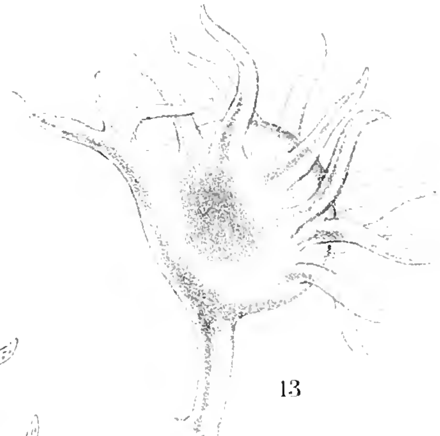

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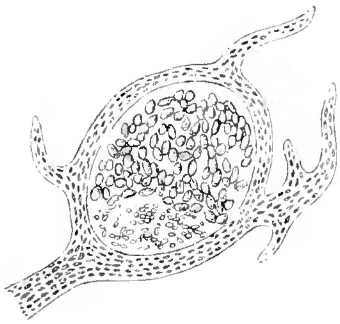

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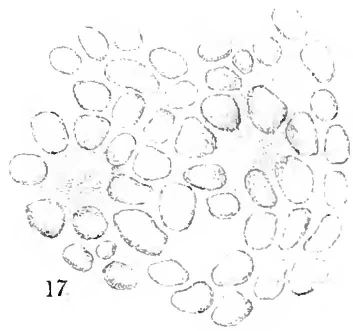

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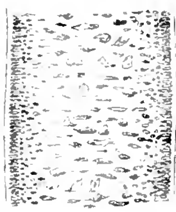

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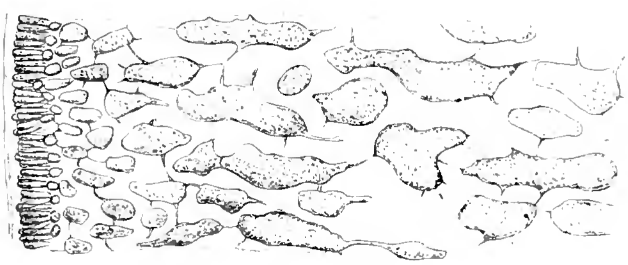

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Antarctic Algæ.

VII.—SOME SOUTH ORKNEY ALGÆ.

VII.—SOME SOUTH ORKNEY ALGÆ.[1]

By E. M. Holmes, F.L.S.

The following list[2] comprises the calcareous algæ submitted to me for identification by Mr R. N. Rudmose Brown, and, in addition, some fragmentary algæ found adhering to these. The specimens were all collected at the South Orkneys during the stay of the Scottish National Antarctic Expedition there from March to November 1903:—

Prasiola crispa, *Ag.*[3] *Sp. Alg.*, p. 146; *Kütz. Tab. Phyc.*, v. tab. 40, f. vi.; *De Toni, Syll. Alg.*, i. p. 142. Saddle Island, Scotia Bay, Ferrier Peninsula, etc.

Very common on rocks up to several hundred feet, wherever there is running water in spring.

Distribution.—The species is cosmopolitan in distribution, including Graham Land and Cockburn Island, Antarctica.

Scytothamnus rugulosus, *De Toni, Syll. Alg.*, iii. p. 454. Scotia Bay, 9–10 fathoms, April 1903.

Distribution.—Also recorded from the Magellan Straits and Falkland Islands.

Cryptonemia luxurians, *J. Ag. Sp. Alg.*, ii. p. 228. Scotia Bay, 9–10 fathoms, April 1903.

The undulate margin and parchment-like consistence of this fragmentary specimen indicate that it belongs to the above species. It is recorded from south polar regions by J. G. Agardh from Montagne's specimens collected in the *Voyage au Pôle Sud*; but Hariot failed to trace it in Montagne's herbarium, and found only *Delesseria Lyallii*, Harv. It is therefore interesting to ascertain that the plant really does occur in the Antarctic Ocean.

Distribution.—Canary Islands, Cape Verde Islands, Brazil, and Martinique.

Iridea, sp. Scotia Bay. Minute cuneate fronds of about 1 cm. long occur on the stones received, in company with the *Lithothamnia*, but it is impossible to determine to which of the species known to occur in the Antarctic Ocean this plant belongs.

Plocamium secundatum, *Kütz. Tab. Phyc.*, xvi. tab. 42. Scotia Bay, 9–10 fathoms, April 1903.

[1] Reprinted from the *Journ. of Bot.*, July 1905.

[2] To this list of calcareous and other algæ, which Mr E. M. Holmes has kindly drawn up for me, I have added some notes on the distribution of the species. I have omitted a few species, also recorded in the lists of Mr and Mrs Gepp.—R. N. R. B.

[3] This species was determined by Mr A. D. Cotton.—R. N. R. B.

The specimens do not exceed 2 cm. in length, and occur on the stones bearing the *Lithothamnia*; but there is no reason to doubt that they belong to this species.

Distribution.—Also recorded from Cape Horn, Hermite Island, and Magellan Straits.

PETROCELIS CRUENTA, *J. Ag. Sp.*, ii. p. 490; *Crouan, Fl. Finist.*, p. 147, tab. 18, f. 122. Scotia Bay, 9–10 fathoms.

This species occurs on the stones bearing the *Lithothamnia*. Although it is not in fructification, the absence of the zonate lines found in *P. Middendorffii*, Kjellm., and the thin basal portion of the thallus indicate *P. cruenta*, J. Ag.

Distribution.—It does not appear to have been previously recorded from the Antarctic Ocean. Known from Europe and North America.

LITHOTHAMNION LICHENOIDES, *Heydr.* f. ANTARCTICA, *Fosl.? List of Sp.* (1898), p. 7; *Svenska Exped. till Magell.*, Bd. iii. No. 4 (1900), p. 70. L. antarcticum, *Heydr. Lith. Mus. Paris* (1901), p. 544. Scotia Bay, June 1903.

Distribution.—Hermite Island, Falkland Islands, and Kerguelen.

L. MAGELLANICUM, *Foslie*, f. CRENULATA, *Fosl. in Kogl. Norske Vidensk. Selsk.* (1904), *New Calcareous Algæ*, p. 3; *op. cit.*, 1895, p. 8, fig. 8. Scotia Bay, 9–20 fathoms, July 1903.

This plant is mixed with the two following on the same stones, but is the least abundant of the three. It differs from the type in having a zonate margin and irregular very shallow prominences on the surface, as in *L. fecundum*, but the surface is less shining than in that species.

LITHOPHYLLUM DISCOIDEUM, *Foslie*, f. ÆQUABILIS, *Fosl. in Kogl. Norske Vidensk. Selsk.* (1904), p. 3; *Svenska Exped. till Magell.*, Bd. iii. No. 4 (1900), p. 73. Scotia Bay, 9–10 fathoms.

This plant has a smooth discoid thallus, with the immersed receptacles visible, only when empty, as a number of circular depressions crowded on the central half of the thallus. The margin is minutely cracked or fissured, as in *L. incrustans*, Fosl.

L. DECIPIENS, *Fosl. in Svenska Exped. till Magell.*, Bd. iii. No. 4 (1900), p. 71. Scotia Bay, 9–10 fathoms.

These specimens are in bad condition, all the sporangia being empty; they are crowded closely over the whole surface of the thallus, giving it a rough or minutely reticulated appearance.

Distribution.—California and Fuegia.

It is remarkable that *L. rugosum*, Fosl., which occurs with *L. magellanicum* and *L. discoideum* on the coast of Patagonia, does not occur on any of the stones from the South Orkneys. It is characterised by the prominent wart-like excrescences on the thallus, like those of *L. colliculosum* Fosl., from which it differs in the character of the sporangia.

VIII.—CALCAREOUS ALGÆ.

VIII.—CALCAREOUS ALGÆ.

By M. Foslie, Trondhjem Museum.

[Editorial Note.—The following account of the two abundant species of calcareous algæ occurring at the South Orkneys is extracted from a paper by M. Foslie dealing with the new calcareous algæ of several of the Antarctic expeditions of recent years (*Kongl. Norske Vidensk. Selsk.*, Trondhjem, 1904, p. 3). The death of Herr Foslie in November 1909 has prevented the revision and amplification of these notes by the author. They are consequently published in their original form. For a fuller account of these two species, and their geographical distribution, reference may be made to M. Foslie's paper on "Antarctic and Subantarctic Corallinaceæ" in *Wissen. Ergeb. Schwed. Südpolar-Exp.*, Bd. iv., Lief. 5, Stockholm, 1907.—R. N. R. B.]

Lithothamnion magellanicum, *Fosl.* f. crenulata, *Fosl. mscr.*

Thallus ikke saa haardt faestet til underlaget som hos den typiske form, kanten mere ujevn og konceptaklerne tildels svagt nedtrykte i midten. Formen staar naermest f. *Schmitzii* (*Har.*) *Fosl. mscr.* (*Lithoph. Schmitzii*, Har.), og den minder ogsaa noget om f. *taltalensis Fosl. mscr.* fra Taltal i Chile. Den sidstnaevnte form udmerker sig ved lidt mindre celler og lettere affaldende konceptakeldaekke end hos den typiske form. —Ny Orkenoerne. Den skotske antarkt. eksp. *Scotia.*

Lithophyllum discoideum, *Fosl. mscr.* f. æquabilis, *Fosl. mscr.*

Skorpen er tyndere og jevnere end hos hovedformen, og i et tversnit viser der sig tildels smaa kvadratiske mellemceller omtrent som hos *Archæolithothamnion.* Arten staar meget naer *L. consociatum* fra Kerguelen. Jeg forbeholder mig derfor senere efter naermere undersogelse at fastslaa dens forhold til disse arter og muligens at opstille den som selvstaendig.—Ny Orkenoerne. Den skotske antarkt. eksp. *Scotia.*

IX.—FRESHWATER ALGÆ OF THE SOUTH ORKNEYS.

IX.—FRESHWATER ALGÆ OF THE SOUTH ORKNEYS.[1]

By F. E. Fritsch, D.Sc., Ph.D., East London College (University of London).

(*With Two Plates.*)

A. INTRODUCTORY REMARKS.

In the year 1905 I received from Dr R. N. Rudmose Brown seventeen tubes of freshwater and subaerial algæ collected by him in the South Orkneys, while acting as botanist to the Scottish National Antarctic Expedition (1902–04). I am glad to have this opportunity of thanking him for placing this interesting material at my disposal.

Our knowledge of Antarctic freshwater algæ is at present not very extensive. The first important contribution was that of Hooker and Harvey,[2] based on the material collected by the *Erebus* and *Terror* in 1839–43. This was followed about thirty-five years later by two papers of Reinsch,[3] containing a description of the algæ collected by the Rev. A. E. Eaton on the island of Kerguelen. A later paper by Reinsch[4] deals with freshwater algæ collected by Dr H. Will in South Georgia. Wille[5] has further described a few forms brought by C. E. Borchgrevink from the Antarctic continent, and De Wildeman a number of algæ collected by E. Racovitza of the Belgian Antarctic Expedition.[6] In 1909, lastly, there appeared the important contribution of Van Heurck on the diatoms of the same expedition.[7]

[1] Revised and reprinted from *Journ. Linn. Soc. Lond., Bot.*, vol. xl., 1912, pp. 293–338.

[2] J. D. Hooker, *The Botany of the Antarctic Voyage of H.M. discovery ships "Erebus" and "Terror" in the years 1839–43* (*Flora Antarctica*), London, 1844: "Algæ" (by W. H. Harvey and J. D. Hooker), vol. i. pp. 175–193; vol. ii. pp. 454–519.

[3] P. F. Reinsch, "Species ac Genera nova Algarum aquæ dulcis, quæ sunt inventa in speciminibus in expeditione Vener. transit. hieme 1874–75 in Insula Kerguelensi a clar. Eaton collectis," *Journ. Linn. Soc., Bot.*, xv., 1876; P. F. Reinsch, "Freshwater Algæ collected by the Rev. A. E. Eaton (Algæ aquæ dulcis Insulæ Kerguelensis): Account of the Petrological, Botanical, and Zoological collections made in Kerguelen's Land and Rodriguez during the Transit of Venus Expeditions, 1874–75," *Phil. Trans. Roy. Soc. Lond.*, vol. 168, 1879, pp. 65–92. See also W. Archer, "Note on the Freshwater Algæ collected by H. N. Moseley in Kerguelen's Land," *Journ. Linn. Soc., Bot.*, xv., 1876, pp. 445–446; E. O'Meara, "On the Diatomaceous gatherings made at Kerguelen's Land by H. N. Moseley, H.M.S. *Challenger*," *loc. cit.*, pp. 55–59.

[4] P. F. Reinsch, "Die Susswasseralgenflora von Sud-Georgien," *Die internationale Polarforschung*, 1882–83. *Die deutschen Expeditionen und ihre Ergebnisse*, Bd. ii., Berlin, 1890, pp. 329–365, Jahrb. i.–iv.

[5] N. Wille, "Mitteilungen uber einige von C. E. Borchgrevink auf dem antarktischen Festlande gesammelte Pflanzen: III. Antarktische Algen (by N. Wille); IV. *Navicula mutica*, Kutz., aus dem antarktischen Festlande (by J. Holmboe)," *Nyt Magazin f. Naturvidenskab*, xl., 1902, pp. 209–222, pl. iii.–iv.

[6] E. de Wildeman, "Note préliminaire sur les Algues rapportées par M. E. Racovitza, naturaliste de l'expédition antarctique belge," *Bull. Acad. Roy. de Belgique*, 1900, pp. 558–569.

[7] Van Heurck, "Diatomées," in *Rés. voyage du s.y. "Belgica" en 1897–99*, Antwerp, 1909, pp. 1–128, pls. i.–xiii. Whilst the present paper has been in the press, there has also appeared Messrs West's report on the Freshwater Algæ

The South Orkneys (lat. about 61° S.) are situated appreciably further south than either South Georgia (lat. about 55° S.) or Kerguelen (lat. about 49° S.), from which most of the previously described material has been derived. This may explain the marked difference in the character of the algal collections obtained from the South Orkneys as compared with those from the other two localities. In the material from the South Orkneys filamentous forms play a very insignificant part, and the bulk of the algæ consists of unicellular and colonial species. The total number of species recorded from the South Orkneys in the present paper is 68 (of these 1 genus and 7 species are new). The table on p. 97 shows how the different groups are represented. This table, however, gives no idea of the relative part played by the different groups. As a matter of fact (apart from the abundant *Prasiola*), the lowly unicellular Isokontæ and Cyanophyceæ are the predominant features of the flora, the former being on the whole more abundant than the latter. In this connection we may notice, however, that the complete absence of common cosmopolitian forms like *Scenedesmus*, *Pediastrum*, *Cosmarium*, *Closterium*, etc., is very striking. The *Œdogoniaceæ*, as indeed all filamentous forms, are represented only by stray filaments. Only two filaments (one of *Mougeotia*, the other of *Zygnema*) of Zygnemaceæ were observed. The occurrence of filaments of the various genera nevertheless testifies to the fact that at certain periods their development must be more prominent. Desmids were represented only in two samples by three species. Diatoms are not common, and in some samples (*e.g.* yellow snow) were almost completely absent. Their determination was in many cases a matter of great difficulty, as frequently only dead fragments of the valves were to be found, and it is probable that a larger number of species actually occurs than is recorded in the present paper.[1] In a number of the samples the unicellular algal flora occurred as a thin covering to numerous muddy particles, and it was necessary to crush the latter in order to find any appreciable number of algal forms.

The lowly unicellular and colonial forms of algæ are well known to be in many cases among the most difficult forms to determine, and to add to this difficulty a very large proportion of the species in the South Orkneys material were in the resting-stage, or at least in a sufficiently dormant condition to fail to show more than one phase in the life-history. This is particularly true of the forms found on the snow (yellow and red snow), but applies to a lesser extent to practically the whole of the material; only in

of the British Antarctic Expedition, 1907–09 (see *Reps. on Scien. Investig.*, vol. i., *Biology*, part vii., 1911, pp. 263–298, pl. xxiv.–xxvi.), while a report on the Freshwater Algæ of the British National Antarctic Expedition by the writer is about to appear. These two collections, which come from a latitude appreciably further south than that of the South Orkneys, however, show an algal vegetation of a decidedly different stamp from that described in the present paper.

[1] The republication of this paper has given an opportunity of reinvestigating the diatom-flora of some of the samples in which those forms occurred more abundantly. This reinvestigation was undertaken with a view to determining whether the flora includes any of the new species described by the Wests (*loc. cit.*), or by the writer in his report on the algæ collected by the *Discovery*, but the result has been a negative one. Common forms like *Navicula Shackletoni*, *N. cymatopleura*, etc., which form such a feature in the *Discovery* collections, and in those made by Shackleton's expedition, were found to be quite wanting, and the aspect of the diatom-flora in the South Orkneys is thus quite distinctive.

one case (samples gathered on February 4, 1903, from a freshwater pond at an altitude of 140 feet, between the peaks of Saddle Island, South Orkneys) were organisms (species of *Chlamydomonas*) present, which had evidently been preserved in an actively motile condition. For this reason it has seemed best to give as complete an account of the material as possible, in the hope that subsequent investigations may lead to a better interpretation of some of the forms observed. This has been carried out especially in the case of the yellow snow flora.

Some of the numerous resting-stages observed are referable to described species of the genus *Trochiscia*, or at least come very close to them; where this was the case, they have been enumerated under the genus *Trochiscia* (see the systematic part of the paper), although it was thought undesirable (except in one case) to establish new species on this basis. It can hardly be doubted that some of the species of *Trochiscia* are merely resting-stages of other algæ, although where a definite course of reproduction has been observed we are probably dealing with independent forms. In the case of the material from the South Orkneys, no evidence as to the authenticity of *Trochiscia* forms was to be expected, since no single case of reproduction was observed; and there was no choice save to record the diverse structures noticed as species of this genus.

On the whole it is astonishing that, considering the abundance of some of the algal forms, only very few reproductive stages were found; in some cases (*e.g.* the *Trochiscias* just referred to, *Chodatella brevispina*) not even an indication of division of the individuals was observed, although the material was collected during the milder portion of the year (October to March). The mean temperature, however, even at this period (as Dr R. N. Rudmose Brown informs me), is only 32° F. It seems therefore as though many of these Antarctic forms reproduce only during very limited periods, when the conditions are especially favourable.

As above stated, the freshwater algal floras of Kerguelen and South Georgia, as described by Reinsch (*loc. cit.*), have a rather different character. The following table shows the relative composition of the algal floras of the two localities and of the South Orkneys:—

	Kerguelen.		South Georgia.		South Orkneys.	
	Genera.	Species.	Genera.	Species.	Genera.	Species.
Isokontæ (incl. Œdogoniaceæ)	25	36 (20 fil.)	17	32 (12 fil.)	17[1]	29 (5 fil.)
Conjugatæ	8	12 (7 fil.)	5	20 (1 fil.)	4	5 (2 fil.)
Heterokontæ	...	...	1	1	1	1
Cyanophyceæ	18	33	5	5	13	18
Diatomaceæ	12	21	10	19	9	15
Phæo- and Rhodo-phyceæ	2	2	...	...	...	...
Totals	65	104	38	77	44	68

[1] A number of these were, however, only found in the yellow snow flora.

Both in Kerguelen and South Georgia the flora is richer in conjugates, especially in desmids, which are responsible for 19 of the 20 species from South Georgia, while in the vegetation of the latter the Cyanophyceæ play a comparatively small part. But it is in the relative number of filamentous forms (species of *Œdogonium*, *Bulbochæte*, *Ulothrix*, *Rhizoclonium*, *Vaucheria*, *Spirogyra*, etc.) present in the flora of Kerguelen and South Georgia, as compared with the South Orkneys, that the difference becomes most striking; in this connection we may also notice that there is a considerable reduction in the number of filamentous forms from South Georgia as compared with Kerguelen. From both localities, also, reproductive material was obtained (*Vaucheria* from Kerguelen, *Vaucheria* and *Œdogonium* from South Georgia). Lastly, we may notice that the common cosmopolitan forms, whose absence from the flora of the South Orkneys was commented upon above, are all recorded by Reinsch either from Kerguelen or South Georgia. It is hardly likely that all these striking differences in the composition of the algal flora of the South Orkneys are purely accidental. They are probably to be ascribed to the geographical position of the South Orkneys and the consequent severer climatic conditions.

To avoid frequent repetition I append a list of the localities in which the different samples were collected; the corresponding number will alone be referred to in the systematic portion of this paper:—

No. 1. Yellow snow. The Beach, Scotia Bay. 7.2.04.
,, 2. Yellow snow. The Beach, Scotia Bay. 27.3.03.
,, 3. Same locality and date as No. 1.
,, 4. Red snow. Scotia Bay. 27.3.03.
,, 5. Red snow from ice-foot, head of Scotia Bay. 29.12.03.
,, 6. Same locality as No. 5, but collected 1.1.04.
,, 7. Algæ from germ-culture from surface water, 62° 52′ S., 25° 00′ W. 16.2.03 (only fungi present).
,, 8 and 9. Scrapings of rocks and mud from pools or streams. Mossy rocks, Scotia Bay. 28.12.03.
,, 10 and 11. Freshwater pond, 140 feet between peaks of Saddle Island, South Orkneys. 4.2.03.
,, 12. Rocks about tide wash. Buchan Bay, South Orkneys. 25.3.03.
,, 13. Mud and damp moss. Point Martin, Scotia Bay. 7.1.04.
,, 14. Mud from penguin rookery. Point Martin, Scotia Bay. 26.10.03.
,, 15. Freshwater pool. Point Thomson, Brown's Bay. 11.03.
,, 16. Stones on north of beach, Scotia Bay. 11.11.03.
,, 17. Mud from moss on rocks at Point Martin, Scotia Bay. 21.10.03.

In the following pages the flora of the yellow and red snow is first dealt with separately, and this is followed by a systematic enumeration of all the species observed.

B. YELLOW SNOW (*cf.* Plates I. and II.).

Three samples of this peculiar type of snow flora were included in the material from the South Orkneys; Nos. 1 and 3 were collected on the same date, February 7, 1904, and agreed almost completely with one another; while No. 2, which was collected about a year earlier, March 27, 1903, was relatively poor in algal forms (perhaps owing to its being the end of the Antarctic summer), consisting largely of hairs and other foreign particles. Apart from this, however, such forms as were present were the same as those found in the other two samples. All three samples came from the same locality.

Samples 1 and 3 contained a very considerable quantity of algal material, and show that the yellow snow flora, when well developed, must form extensive masses. In reply to inquiries, Dr R. N. Rudmose Brown has very kindly furnished me with the following particulars. I quote from his letters: "Both red and yellow snow are rare at the South Orkneys, and many apparent cases of the latter which I examined were due only to penguin manure. The samples I sent you were taken towards the end of the summer on a snow-covered plain called The Beach, that was certainly often frequented by penguins, but did not contain a rookery. The samples were gathered on the surface of snow that had fallen some little time past,—perhaps two or three days,—and whose surface had been slightly melted by the sun. I do not remember ever seeing any coloured snow in winter, but at that season snow was falling so continuously and drifting so incessantly that any growth would be immediately covered over. October to February is the warmest season, but the mean temperature even then is not above 32° F. . . . The colour of the yellow snow is fairly bright. I do not remember any brown snow, nor have I any record of a green patch being mixed with a yellow one. The algæ were on the surface and perhaps two or three or even four millimetres down mixed with the snow, but in sufficient abundance to give an unmistakable pale (bright yellow) patch. Yellow and red snow were quite distinct from one another; they may in places have been within thirty or fifty yards of one another, but this was not habitual, and I do not remember a single case of the two adjoining one another."

A considerable number of papers have been published dealing with the type of algal flora known as red snow,[1] which has been recorded from Alpine (temperate and tropical), Arctic, and Antarctic localities. Brown and green snow have also been described both from Alpine and Arctic regions,[2] while Rostafinski[3] has recorded yellow snow

[1] See section *C* of this paper; also J. Roy, "The Flora and Fauna of Snow and Ice," *Scottish Naturalist*, viii., 1885–86, pp. 122–127.

[2] V. B. Wittrock, "Om snöns och isens flora," in Nordenskiöld's *Studier och Forskningar föranledda at mina resor i höga norden*, Stockholm, 1883, pp. 65–115. See also V. B. Wittrock, "Die Flora des Schnees und des Eises besonders in den arktischen Gegenden," *Bot. Centralbl.*, xiv., 1883, p. 159; E. Warming, *Œcology of Plants* (Eng. trans. by P. Groom), Oxford, 1909, p. 163.

[3] J. Rostafinski, "Vorlaufige Mitteilung uber rothen und gelben Schnee und eine neue in der Tatra entdeckte Gruppe von braungefarbten Algen" (Polish), *Sitzungsber. d. Krak. Akad. d. Wissensch.* (mat.-nat. sect.), 1880; Abstract in *Bot. Centralbl.*, viii., 1881, p. 235, and Just's *Botan. Jahresber.*, 8 (1880), i., 1883, p. 564.

(apparently due to a species of *Chlamydomonas*) on the snowfields of the Carpathians. Chodat,[1] lastly, also refers to black snow (neige noir), and describes a yellowish-orange organism, *Pteromonas nivalis*, Chod., as occurring in it. All these different types of snow flora, however, appear to be markedly distinct from the yellow snow collected in the Antarctic, and I have therefore thought it expedient to deal with this part of the South Orkney material separately.

The organisms composing the yellow snow flora are in part similar to or identical with some of those found in red and other coloured snow, but there are a number of very distinct types (e.g. *Protoderma brownii*, *Chlorosphæra antarctica*, *Scotiella antarctica*, and *Chodatella brevispina*) that give this association a characteristic stamp. There seems some probability that the yellow snow flora is an example of what I have called an algal consortium,[2] in which certain members (*Protoderma brownii*) first prepare a suitable substratum for the growth of the others; but this could of course only be definitely settled by observations made on the spot. All the typical and common members of the yellow snow flora include a varying (but often very large) quantity of an apparently solid fat in their cell-contents, which appears in the form of large, highly refractive lumps.[3] The amount of this fat is often so considerable that little can be seen of the remaining cell-contents, while in other cases, and often quite inexplicably, the fat is completely absent. It appears that the yellow pigment, which is the cause of the characteristic colour of the yellow snow, is included in this fat, although, as most of the pigment had been dissolved out by the preserving fluid, I cannot be certain with reference to this point. I have been unable to make out the nature of the pigment, owing to the small quantity that was available; a spectroscopic examination of the alcohol in which the one sample was preserved disclosed a marked absorption of the violet end of the spectrum, which would indicate that the pigment might be analogous to carotin or xanthophyll, but none of the other reactions characteristic of this substance were obtained. As regards the fat, neither in its general appearance under the microscope, nor in its behaviour towards the various reagents used (*cf.* footnote [3] below), was there anything to indicate a difference between the

[1] R. Chodat, *Algues vertes de la Suisse*, Berne, 1902, pp. 96 and 145–146. See also Brun, "Sur la neige noir," *Echo des Alpes*, 1875, p. 182.

[2] F. E. Fritsch, "Problems in Aquatic Biology," *New Phytologist*, vol. v., 1906, pp. 157–158.

[3] These lumps gave all the characteristic fat-reactions (*cf.* Zimmermann, *Die botan. Mikrotechnik*, Tübingen, 1892, pp. 68–71). Material treated with osmic acid acquires a very characteristic appearance; there is so much fat in the different forms that the whole mass becomes black to the naked eye, while material thus treated and mounted on a slide presents the appearance of numerous black dots when held up to the light. Under the microscope many of the cells appear stained a homogeneous black, while parts of other cells are quite uncoloured owing to restriction of the fat to one or two points in the cell-contents. Material of yellow snow, treated respectively with alcohol and ether for two and a half days, was scarcely affected by the alcohol, although much of the fat was dissolved out by the ether. Even material which had been left in absolute alcohol for over three months failed to show any marked reduction in the amount of fat, so that the fat is one which is insoluble in alcohol. In the case of the material placed in ether, a macroscopic change was visible after a few hours; the algal mass no longer formed a sediment at the base of the tube as at first, but was separated from the base by a clear space, consisting of ether in which large numbers of roundish fat-globules could be seen floating about under the microscope. The actual cells were very much poorer in fat, although by no means all of the latter could be removed except by very prolonged treatment with ether. The fat

kind of fat present in the various members of the yellow snow flora. The occurrence of the fat and the associated yellow pigment is therefore a very characteristic feature of this algal association.

The enormous prevalence of fat in the members of the yellow snow flora is probably to be regarded as an adaptation against the intense cold of the habitat. It has been shown that in a number of trees (birch, conifers) growing in cold localities the starch is changed into fat in the autumn,[1] and in referring to this fact Warming[2] remarks: "This is probably of use, in that fatty oil in the form of emulsion prevents sub-cooling, and increases the power of resistance to frost." This view is certainly much strengthened by the discovery of the yellow snow with its striking characteristic of fat-storage. A similar abundance of fat does not appear to have been recorded hitherto in any snow-flora.[3] The fact that the few reproductive stages that were observed in the yellow snow material were generally quite deficient in fat also indicates that the latter possibly functions as a reserve, to be utilised when outside conditions admit of cell-division or other methods of reproduction taking place.

In most cases the organisms found on snow and ice contain some characteristic pigment (red hæmatochrome in the case of *Chlamydomonas* (formerly *Sphærella*) *nivalis* (Sommerf.), Wille; violet or purple phycoporphyrin in the case of *Ancylonema Nordenskiöldii*, Berggr.), although green snow (due to filamentous algæ, desmids, and cyanophyceæ) has also been described. Similar pigments are found in members of many other types of algal floras, but there is certainly a prevalence of pigmentation in forms occurring on the snow. It has been pointed out that these pigments are capable of absorbing the heat-rays of the sun,[4] and it is also possible that they may serve to screen the chlorophyll during the long summer.[5] It is difficult to express an opinion on the function of the yellow pigment colouring the organisms of the yellow snow, but it is possible that it acts in one or both of these ways. In support of this it is noticeable that the *Protoderma*, which presumably forms a sheet on which the other forms settle down, is on the whole very poor in fat and pigment, perhaps because it is screened by the overlying forms from the light.

We may next proceed to consider the various organisms that are distinguishable in the yellow snow flora. Apart from a number of resting-stages, which could not be

also took on the typical red stain with tincture of alkanna. On the other hand, even prolonged treatment (36 hours) with equal parts of concentrated caustic potash and ammonia solutions, although it made the fat more transparent, failed to bring about proper saponification.

[1] A. Fischer, "Beiträge zur Physiologie der Holzgewächse," *Pringsheim's Jahrb.*, xxii., 1891; O. G. Petersen, "Stivelsen hos vore Troer under Vinterhvilen," *Danske Vid. Selsk. Oversigt*, 1896; *cf.* also Schimper, *Plant Geography* (Eng. trans.), Oxford, 1903, p. 41.

[2] Warming, *Œcology of Plants* (Eng. trans. by P. Groom), Oxford, 1909, p. 23.

[3] *Ibid.*, p. 163.

[4] *Cf.* V. B. Wittrock, "Die Flora des Schnees und des Eises besonders in den arktischen Gegenden," *Bot. Centralbl.*, xiv., 1883, p. 159; Warming, *loc. cit.*, p. 163.

[5] *Cf.* Chodat, *Algues vertes de la Suisse*, Berne, 1902, p. 74. Hæmatochrome certainly acts as a screen to the chlorophyll in other algæ (e.g. *Trentepohlia*); *cf.* Oltmanns, *Morph. u. Biol. d. Algen.*, ii., Jena, 1905, p. 200.

determined, 18 species of algæ and 2 fungi are concerned in the production of this association. The algæ observed are the following:—

Protoderma brownii, n. sp. (p. 102).
Chlorosphæra antarctica, n. sp. (p. 103).
Scotiella antarctica, n. gen. et sp. (p. 105).
,, *polyptera*, n. sp. (p. 108).
Pteromonas nivalis, Chod. (p. 109).
Chodatella brevispina, n. sp. (p. 111).
Oocystis lacustris, Chod. f. *nivalis*, n. f. (p. 112).
Sphærocystis schroeteri, Chod. f. *nivalis* n. f. (p. 113).
Trochiscia antarctica, n. sp. (p. 116).
Raphidonema nivale, Lagerh. (p. 116).
Raphidium pyrenogerum, Chod.? (p. 117).
Ulothrix subtilis, Kütz.
Œdogonium, sp.
Pleurococcus vulgaris, Menegh.
Chlamydomonas caudata, Wille.
,, sp. (p. 118).
Mesotænium endlicherianum, Naeg.
Nostoc minutissimum, Kütz.

A considerable number of these forms will be considered in detail in the following paragraphs.

(*a*) PROTODERMA BROWNII, n. sp. (Pl. I., fig. 1; Pl. II., phots. 1, 2, 3, 5, *P*).

The main ground-mass is constituted by a form, which I somewhat doubtfully refer to the genus *Protoderma* as a new species, *P. brownii*, n. sp. (Pl. I., fig. 1). This alga probably forms broad sheets of cells, with an irregular margin spread out on the surface of the snow, and may possibly serve as a basis for the growth of some of the other forms (*cf.* p. 100). A rough examination discloses merely a number of more or less rounded green protoplasmic masses, regularly arranged with reference to one another, and separated by marked colourless intervals. The latter are due to the cell-walls, which are markedly gelatinous; a careful examination (especially of material stained with gentian violet or methylene blue) reveals the polygonal (sometimes rather rounded) network due to the middle lamellæ of the walls and the (occasionally stratified) mucilage, which intervenes between middle lamella and cell-contents. The middle lamellæ frequently exhibit a granular character. Where the cell-contents are not obscured by the above-mentioned fat (which was frequently quite wanting in the cells of the *Protoderma*, *cf.* p. 101), it is possible to make out a single chloroplast, which generally takes the form of a curved plate, and may frequently be almost hemispherical. In preparations stained with gentian violet a single pyrenoid was often to be distinguished in the chloroplast, while iodine generally showed the presence of a limited number of starch-grains in the cells. In rare cases adjoining cells of relatively small size were separated by thin and delicate walls; such cells are no doubt daughter-cells produced by division, prior to preservation of the material. These young daughter-cells nearly always contained fat. On the whole, however, the *Protoderma* seemed in as inactive a condition as the other constituents of this snow flora. The cells vary considerably in size, from 5–12 μ or even more, but small cells are the rule; in most places they form but a single layer, but, where extensive patches of the *Protoderma* were observed, they appeared to lie in two (or more?) layers above one another.

The remaining species of the genus *Protoderma* are characterised, according to recent descriptions,[1] by the thallus consisting of a central group of irregularly arranged cells from which short filaments radiate out at the periphery. Of this feature *Protoderma brownii* shows nothing, the edge of the thallus in all cases presenting just as irregular an arrangement of the cells as obtains in the middle. *P. brownii* also differs from the other species of the genus in not being an epiphyte (*cf.* however p. 127). Rabenhorst's[2] figure and description of *P. viride*, Kütz., however, give no indication of any regular arrangement of the cells, and the same is true of Migula's recent description, which even refers to the cells as being "ordnungslos" and "nicht in Reihen."[3] The latter's description of *Protoderma* also recalls the Antarctic form, in that he speaks of the thallus as "schleimig." This character is also referred to in Hansgirg's description,[4] which further contains a statement (on p. 225) as to the occurrence of oil drops in the cells. It will therefore be evident that all the characteristic features of *P. brownii* have already been referred to in the descriptions of *P. viride*, and it may ultimately prove to be but a form of the latter. For the present, however, it seems best to keep it as a distinct species, characterised by the irregular arrangement of the cells, the mucilaginous and granular character of the walls, and the frequent presence of fat in the cell-contents.[5]

(*b*) Chlorosphæra antarctica, n. sp. (Pl. I., figs. 2–6; Pl. II., phots. 1, 3, 5, 6, *C*).

The next most abundant form is a new species of *Chlorosphæra*, which may be called *C. antarctica*, n. sp. (Pl. I., figs. 2–6). This is found either in the form of large isolated cell (figs. 2, 6) or as groups of smaller cells, commonly in fours or sometimes larger numbers (Pl. I., fig. 3); the average diameter of the cells varies between 11 and 26 μ, although smaller and much larger cells were also observed. The cells are provided with a well-defined rather thick membrane, which, especially in the case of the isolated cells, is often surrounded by a wide spherical sheath of transparent mucilage (Pl. II., phots. 1, 3), to the outer edge of which numerous small foreign particles were generally adhering (Pl. I., fig. 2). The isolated cells were mostly more or less spherical in shape, while those forming groups were somewhat angular, probably as a result of mutual pressure. In many cases an almost spherical chloroplast could be made out in the cells without much difficulty; this chloroplast is only interrupted on one side of the cell by a small circular aperture, through which a small round body (in all probability the pyrenoid) can be seen (Pl. I., fig. 2). Starch is mostly present in small quantities in the smaller cells, but is often scarcely to be found in the larger ones. On the other hand, large masses

[1] G. S. West, *The British Freshwater Algæ*, Cambridge, 1904, p. 204, and fig. 83 A–C; N. Wille, "Conjugatæ and Chlorophyceæ," in Engler and Prantl, *Die natürl. Pflanzenfamilien*, Nachtr. z. 1 Teil, 2 Abteil. (Leipzig, 1909), p. 89; *cf.* also Hansgirg, *Prodromus d. Algenflora v. Böhmen*, i. (Prague, 1886), p. 22.

[2] L. Rabenhorst, *Flora europæa algarum aquæ dulcis et submarinæ*, iii., Lipsiæ, 1868, pp. 288 and 307.

[3] W. Migula, *Kryptogamenflora von Deutschland, Deutsch-Österreich und der Schweiz*, II., 1 Teil, Gera, 1907, p. 747; *cf.* also Wille, *loc. cit.*, 1 Teil, 2 Abteil., 1897, p. 78.

[4] "Meist schlupferig," according to Hansgirg, *loc. cit.*, p. 224.

[5] A full diagnosis of *Protoderma brownii* will be found on p. 126. It seems very probable that the form shown by Wittrock ("Om snöns och isens Flora," *loc. cit.*) in his fig. 17 (pl. iii.) belongs to this species, although the cells are more regularly arranged than in my form.

of the above-mentioned fat were nearly always present in both kinds of cells, although certainly more abundant in the larger ones (Pl. I., figs. 2, 4, 5, 6). In a few cases the fat was apparently diffused rather equally throughout the contents of the cells, but it mostly formed very characteristic, highly refractive lumps at one or more points immediately beneath the cell-wall. Frequently it appears in the form of concavo-convex lumps on one side of the cell, the mass of fat fitting like a cap over the protoplasmic contents (Pl. I., figs. 2, 6); occasionally this cap may even grow out of all proportion and give rise to a huge bulging mass on one side of the cell, which thus acquires an unusual shape. More rarely the fat forms a complete sheath, with a rather irregular inner boundary around the protoplasmic contents. Apart from the cases as yet described, in which the fat exhibits an obvious connection with the cell-contents, a number of cells were always to be found in which there were a number of rounded or oval lumps of fat completely segregated from the somewhat contracted protoplasm of the cell, and lying in a more or less well-marked space between the latter and the cell-wall (Pl. I., figs. 4, 5). The cells concerned were always somewhat oval in shape, and showed the pyrenoid and the characters of the chloroplast very prominently. In a few cases (Pl. I., fig. 5) two pyrenoids were visible through the drawn-out aperture in the chloroplast, and this seems to indicate that these oval cells were about to divide. On the whole, such cells contained a relatively smaller amount of fat than the ordinary spherical cells do, and it would thus appear as though this segregation and diminution in the amount of fat precedes cell-division. Some uncertainty, however, naturally attaches to this interpretation until the actual process of cell-division has been observed. The conclusion that the large spherical cells, with their transparent mucilage-sheath, and the groups of smaller cells belong to one and the same species may also be challenged; but apart from the identical structure of the cell in the two cases, I have found practically all transitions between the two sizes, and I think there can be little doubt that they all belong to the same species. The genus *Chlorosphæra*[1] is characterised by its chloroplast and the power of vegetative division (which distinguishes it from the allied genus *Chlorococcum*), and by reproducing by subdivision of the cell-contents to form zoospores[2]; the absence of the latter method of reproduction in *C. antarctica* is not astonishing in view of the dormant character of the whole of the yellow snow flora. The new species seems to come nearest to *C. angulosa*, Klebs,[3] in which Artari states that reproduction principally takes place by vegetative division; *C. antarctica*, however, differs in the often appreciably smaller size of the cells after division, in the mucilage-sheath around the larger cells, and in the faculty of storing up large quantities of fat.[4]

[1] *Chlorosphæra* is included by G. S. West (*British Freshwater Algæ*, p. 202) and some other authorities in the genus *Pleurococcus*, which is not in agreement with the views of Klebs, Artari, Wille, Oltmanns, etc.

[2] Klebs, "Ub. d. Organisation einiger Flagellatengruppen, etc.," *Unters. Bot. Inst.*, Tubingen, 1881–85, p. 343; Artari, *Unters. üb. Entwickl. u. Syst. einiger Protococcoideen*, Diss., Moscow, 1892, p. 35.

[3] *Cf.* Artari, *loc. cit.*, p. 36.

[4] Storage of fat is also found in *Pleurococcus rufescens* (Kutz.), Bréb., which appears to be a species of *Chlorosphæra*. A full diagnosis of *Chlorosphæra antarctica* is given on p. 123.

(c) Scotiella antarctica, n. gen. et sp. (Pl. I., figs. 7–17; Pl. II., phots. 1, 4, 6, *Sc*).

The two species so far considered are by far the most abundant forms in the yellow snow flora, and the remaining members, although many of them not uncommon, are quite subsidiary to them. Among the latter is a very striking unicellular organism, which I regard as the type of a new genus, *Scotiella*.[1] I have observed two species of this genus, one of which (*S. antarctica*, n. sp.) is very much commoner in the yellow snow than the other, of which indeed only very few individuals were seen. Specimens of *S. antarctica* were always to be found to the number of several in every sample of yellow snow examined (*cf.* Pl. II., phots. 1, 6). The most prominent feature of this organism lies in the possession of six longitudinal wing-like extensions (briefly referred to as "the wings" in the subsequent description) of the wall, which run in a perfectly straight manner from one end of the oval cell to the other (Pl. I., figs. 7–11). The six wings are placed at equal intervals round the circumference of the cell, so that they form angles of 60° with one another; this is very well seen in individuals viewed from the end (*i.e.* in optical section, Pl. I., fig. 11), which have a very characteristic stellate appearance. Ordinarily, however, the cells are seen from the side, their general shape being oval, while the wings appear as follows (Pl. I., figs. 7, 10, 12): two of them lie flat with reference to the substratum, and present themselves as lateral extensions (fig. 7, 1 and 2) of the body of the cell, each of them about one half the width of the latter; two further wings, *i.e.* those projecting towards the observer (fig. 7, 3 and 4), appear as arched lines running over the surface of the cell from one end to the other and most obvious at a high focus, whilst at a lower focus two other longitudinal arched lines (representing the pair of wings running on the under side of the cell) are visible.[2] In no case have I observed more or less than six wings. The actual behaviour of the wings at the two ends of the individual proved rather difficult to determine, but I think there can be no doubt that they run as follows:—It appears that one pair of opposite wings (which may be termed the principal wings) runs equatorially round the oval cell as a uniform expansion of the body (1 and 2 in figs. 7, 8, 9, and 11, *p.w.* in fig. 8), this expansion being rather wider at the sides than at the two ends of the cells. In the other two pairs of wings (lateral wings), the wings of each pair form an angle of 60° with one another and with the principal wings, these pairs being 3, 4, and 5, 6 in fig. 11.[3] At the two ends of the cell the wings of each lateral pair become very slightly arched out, and then dip in suddenly and meet together, so that a kind of apparent sinus is formed at the two ends on either side of the principal wings (*cf.* fig. 7, and especially figs. 8 and 9, which are oblique end-views of *S. antarctica*, showing only the course of the wings). The customary position of an individual of *S. antarctica* is

[1] Named after the *Scotia*, the vessel which conveyed the members of the Scottish National Antarctic Expedition.

[2] These wings are not shown in any of the figures representing side-views of the organism.

[3] In an optical section, such as fig. 11, there is nothing to distinguish the different wings from one another, and the numbering is purely arbitrary for the purposes of description.

with the principal wings parallel to the substratum, as shown in fig. 7 (also Pl. II., phot. 4); in this case, as the figure indicates, the two ends of the cell appear completely rounded. But not uncommonly individuals are to be found, in which wings 3, 6, or 4, 5 are parallel to the substratum (*cf.* fig. 10), and in such cases there is a prominent papillose protrusion at each end of the cell, due to the fact that the principal wings project further at these ends than do the lateral wings; a glance at figs. 7 and 9 should make this quite clear. The wings themselves are solid extensions of the wall, into which the cell-cavity does not penetrate (*cf.* fig. 11); they are conical in section, being broadest where they arise from the main body of the cell, and gradually narrowing down to a rounded edge (fig. 11). In the side-views of the cell a very faint stratification of the solid wings could occasionally be observed, especially in stained preparations. At the middle of its longitudinal course each wing is provided with a slight but perfectly distinct notch (Pl. I., figs. 7, 10, 12; Pl. II., phot. 4), which divides into two symmetrical halves; this is an absolutely constant feature. The wings are quite rigid and stand off stiffly at right angles to the surface of the cell; in a drop of water the cells can be made to roll over and over without any apparent bending of the wings taking place.

The cell-contents of *S. antarctica* were very difficult to decipher. It has been impossible to make out any details as to the shape of the chloroplast, which, however, appears to be single. Staining with iodine or hæmatoxylin sometimes brings out a small round body (figs. 11 and 13), which may be either a nucleus or pyrenoid, probably the latter. As a general rule, very little or no starch was demonstrable in the cell-contents, although occasional cells contained quite a lot. The abundant presence of the yellowish-white fat in the contents makes them astonishingly similar to those of *Chlorosphæra antarctica*. As in the latter case, the distribution of the fat shows considerable diversity. The contents mostly occupied the whole body of the cell, and in such cases the granular protoplasm is found in the middle, and a cap of fat at each end of the cell-cavity; commonly these two caps of fat are roughly equal in size and more or less concavo-convex in shape, the concave side having an irregular outline, and being directed towards the granular protoplasm in the centre of the cell. In other individuals two additional lumps of fat on either side of the cell occurred together with the other two masses. In some individuals, finally, the whole of the protoplasm was obscured by the fat, such cells presenting an opaque, yellowish-white, and homogeneous appearance.

Owing to the very marked similarity of the cell-contents in *Scotiella antarctica* and *Chlorosphæra antarctica*, I was at one time inclined to regard the large isolated cells of the latter as resting-stages of the *Scotiella*. This view seemed to obtain additional support from the fact that now and again an individual of *S. antarctica* is to be found in which the contents appear rounded off (Pl. I., fig. 16), and look very similar to a large *Chlorosphæra*-cell (except for the absence of the mucilage-envelope). There is, however, a good deal that speaks against such an assumption. In the first place, it would appear as though the *Scotiella* forms resting-cells of a rather different type (*cf.* fig. 15 and the subsequent description). There is, further, an absence of connecting-stages between the normal *Scotiella*-individual and the *Chlorosphæra*-cells (saving such a stage as is shown in fig. 16). And, lastly, the *Chlorosphæra*-cells, as above mentioned, are of very diverse dimensions, whereas the range of size of the *Scotiella*-individuals is small; and I have never met with any small enough to give rise to resting-cells of the dimensions found in the smaller *Chlorosphæra*-cells. The cells of the latter (even the largest) are, moreover, occasionally found in considerable masses (twenty to fifty or more), separated from one another only by their mucilage-envelopes, which then often become polygonal as a result of mutual pressure; this is much more like what we should expect in a *Chlorosphæra*, than in resting-cells of a form like the *Scotiella*, occurring as it does as isolated individuals. My object in discussing this point in detail has been to avoid the immediate adoption of an assumption which at first sight seems very plausible. At the same time, I do not wish to deny that, with only the present material available for investigation, we cannot completely dismiss the possibility of certain of the large *Chlorosphæra*-cells ultimately proving to belong to the life-cycle of *S. antarctica*;[1] it does not, however, seem probable.

In the course of the previous paragraph reference was made to resting-cells of *Scotiella*, which appear to arise in the following way (Pl. I., figs. 12–15). Rather rarely one finds individuals of this alga in which the contents are markedly contracted or more or less rounded off (figs. 12, 13, also 16); in such cases some or all of the wings appear irregularly folded and stratified, so that they no longer show up so markedly (*cf.* figs. 12 and 16). Various stages of this kind have been found which seem to form a complete series connecting the normal *Scotiella*-individual with large, thick-walled resting-cells (fig. 15), the general shape of which is rounded, while the membrane is double, with a more or less undulated outer layer. The formation of these resting-cells (akinetes) appears to be initiated by a swelling up of the wall of the individual, and the rounding off of its contents; as a result of the swelling of the wall the outline of the wings is obscured, while the wall becomes more or less rounded off around the contracted contents (*cf.* figs. 13, 14); at the same time a stratification becomes apparent in the swollen wall, which subsequently becomes more strongly and markedly thickened (figs. 14, 15). The contents appear to undergo a gradual change during the formation of the resting-cells. At first (fig. 13), as in the ordinary individuals, we have a central mass of granular protoplasm with a cap of fat at either end; as the contents round off, however, this fat disappears (used in forming the thick wall?), and the mature resting-cell contains only granular protoplasm (fig. 15)—possibly with a certain amount of fat diffused through it. Resting-cells of the type just described are fairly common in parts of the yellow snow material, but I have not met with any structures which could be interpreted as germination-stages of these cells; their further fate must therefore at present remain an open question.

[1] If so, they might prove to be germination-stages of the resting-cells described in the next paragraph, but there is no evidence for this.

One other possible stage in the life-history of *S. antarctica* has been observed (Pl. I., fig. 17). This consists of a delicate, more or less oval membrane surrounding four oblong individuals of irregular shape, in some of which a pyrenoid was discernible; the irregular shape is due to the formation of various outgrowths on the surface of each individual. I have rather tentatively regarded these four cells as *Scotiella*-cells in the making, the outgrowths, which appear to be solid, being interpreted as the developing wings. Only two such stages have been observed, and they were both in the same condition, so that future observations must show whether the above interpretation is correct. Certainly no great stretch of the imagination is necessary to derive an ordinary *Scotiella*-individual from the oblong cells seen in fig. 17. If these stages really belong to the *Scotiella*, we still require to know whether they represent the division of an ordinary individual or of a resting-cell.

We may next proceed to consider the systematic position of *Scotiella*. In view of our rather incomplete knowledge of the organism, its affinities are not easy to determine, but I am inclined to regard it as a fairly close ally of the genus *Oocystis*, from which it differs chiefly in its characteristic wings, and in the marked storage of fat. Should fig. 17 actually represent a reproductive stage of an ordinary individual of *S. antarctica*, then the latter organism would reproduce in a very similar way to *Oocystis*. The cells of the latter are described [1] as having one or more parietal chloroplasts with or without pyrenoids; so that the probable occurrence of a single chloroplast with a pyrenoid in the *Scotiella* does not speak against a relationship with *Oocystis*. The latter genus is included by Oltmanns [2] in his Scenedesmaceæ, while Wille refers it to the Oocystaceæ.[3]

Before concluding the discussion of *S. antarctica*, reference must be made to the fact that the resting-cells (fig. 15) above referred to this species show considerable resemblance to *Trochiscia insignis* (Reinsch), Hansg. (= *Acanthococcus plicatus*, Reinsch), and to *T. obtusa* (Reinsch), Hansg. (= *A. obtusus*, Reinsch).[4] In the former case the cells are much larger than the resting-stages ascribed to the *Scotiella*, but in the latter case the dimensions approximately agree. It would, however, be inadvisable at the present moment to attempt any further comparison between these forms.

(*d*) Scotiella polyptera, n. sp. (Pl. I., figs. 18–21).

The second species of *Scotiella*, *S. polyptera*,[5] n. sp., was, as above stated, only rarely found in the yellow snow material, but rather more abundantly in samples 11 and 15, from which all the figures were drawn (Pl. I., figs. 18–21). The material of this species was, however, so scanty, and the state of preservation of the

[1] *Cf.* Wille, *loc. cit.*, p. 58.

[2] Oltmanns, *Morph. u. Biol. d. Algen*, vol. i., Jena, 1904, p. 183 *et seq.*

[3] A full diagnosis of the new genus and species, with measurements, will be found on p. 125.

[4] *Cf.* Migula, *Kryptogamenfl. v. Deutschland, Deutsch.-Österreich u. d. Schweiz*, ii. 1, p. 634, and pl. 35, E, fig. 5, pl. 35, F, fig. 10.

[5] πολὺς, many; πτερὸν, a wing.

individuals so bad in most cases, that only a brief description can be given. The cells are oval, and of considerably smaller dimensions than those of *S. antarctica*; in place of the six wings of the latter the cells are provided with numerous longitudinal wings, which generally have a somewhat spiral trend (fig. 18, and especially figs. 19 and 21). The wings do not stand off from the body of the cell nearly as prominently as in *S. antarctica* (*cf.* especially fig. 20, which is an oblique end-view of the organism). Each of the wings is undulated (fig. 18), and this fact, together with the large number of the wings, makes the cells present a notched crenate outline from whatever point they are viewed (*cf.* figs. 20, 21). At the two ends of the cells the wings bend inwards, and terminate in a shallow sinus (fig. 20, also 21 and 18). The wings are solid, as in the other species, and appear as flat crenations in optical section (fig. 20). As regards the contents of the cells of *S. polyptera*, in the few cases in which they could be made out at all there appeared to be a single chloroplast with a prominent pyrenoid (fig. 21); fat was not observed in the cell-contents of this species. Only one case of possible reproduction was found (fig. 19); a cell of *S. polyptera*, in which the outline of the wings had become obscure (visible, however, as delicate spiral lines in the right-hand portion of fig. 19), contained a number of elongated protoplasmic masses, in one of which a pyrenoid was prominent. This stage is possibly to be interpreted as division of the contents of the individual to form a number of daughter-individuals; if this is so, it of course constitutes a marked analogy to the probable stage of *S. antarctica* shown in fig. 17. It may be added that the individuals of *S. polyptera* were not uncommonly found in groups of four or five, which would quite accord with their being formed by subdivision of a mother-individual.

S. polyptera is obviously of a more dubious character than *S. antarctica*. While some doubt may justly be felt as to its independence (for it might be the zygospore of some form?[1]), it is impossible to feel quite certain of its close affinity to *S. antarctica*, and further observations may warrant its removal from the genus *Scotiella*. In view of the bad definition of the wings in all the cells observed, I am inclined to think that no normal individuals of *S. polyptera* were present in my material, and that all the forms observed were either preparing for division or passing over into some resting-stage.[2]

(*c*) Pteromonas nivalis, Chod. (Pl. I., figs. 22–24, 31).

Another form, of which, however, only very occasional specimens were met with in the yellow snow material, is represented in figs. 22–24 and 31 of Pl. I. This is almost

[1] I have not, however, met with anything to countenance this view. Lagerheim ("Schneeflora des Pichincha," *Ber. Deutsch. Bot. Ges.*, x., 1892, p. 529; also "Schneeflora in Lulea Lappmark," *Bot. Centralbl.*, xvi., No. 11, 1883) refers to oval cells (15 μ broad and 30 μ long) as occurring in red snow from Amsterdamö (Spitsbergen). These cells are described as having longitudinal ridges, and may possibly represent the same form as *S. polyptera*, or a closely allied one. Lagerheim, however, regards these cells as probably being zygospores of *Chlamydomonas lateritia* (*cf.* p. 111, footnote 1).

[2] A diagnosis of *Scotiella polyptera* is given on p. 125.

certainly Chodat's *Pteromonas nivalis*.[1] The individuals are of an elongated oval shape, and provided with a number of wings, which are rather sinuous and have a more or less marked spiral course (figs. 22–24). The number of wings has been determined as eight in individuals seen from the side, although none were seen in optical section, as Chodat figures them (his fig. 70, H and J). The behaviour of the wings at the two ends of the cells could not be exactly determined, but it would seem (fig. 23) as though they projected somewhat at these points so as to give rise occasionally to the appearance of a terminal papilla (*cf.* also Chodat's fig. 70, B, C, K); all the wings appear to run together to a common point. In the cell-contents an irregularly shaped, more or less central chloroplast with a pyrenoid was often visible, and a considerable amount of the characteristic fat was mostly present.[2] No reproductive or resting stages were observed.

It seems to me that the reference of this species to the genus *Pteromonas* is in no way certain.[3] The genus includes a number of species, which are actively motile forms provided with two cilia. In the case of *P. nivalis*, however, no cilia have been recorded, nor was I able to make out any traces of them in the yellow snow specimens. On this point Chodat (*loc. cit.*, p. 146) remarks, "cellules parfois mobiles, ordinairement immobiles; cils inconnus." Wille,[4] in his later description of this species, does not refer to any movement; in fact, he regards the winged cells as resting-stages (aplanospores), and looks upon certain cells ("spindelförmige, an dem einen Ende etwas abgestumpfte Zellen," p. 168), which he figures on pl. iii., fig. 46 (*cf.* Chodat's fig. 70, F), as zoospores of the *Pteromonas*, which had come to rest; possibly my fig. 31 may correspond to these cells. In view of the fact, however, that neither Chodat nor Wille nor I have seen any trace of cilia on either type of cell, these interpretations appear somewhat forced. A much simpler view would be to regard the typical winged form (as shown in Chodat's fig. 70, A, B, C, and my figs. 22–24) as the normal motionless individual, and the unwinged cells (Chodat's fig. 70, F, Wille's fig. 46, and my fig. 31) as young individuals, possibly formed by division of the contents of a mother-individual, and in which wings have yet to arise (*cf.* Chodat's fig. 70, N); the correctness of this view depends mainly on the nature of the movement observed by Chodat. If my interpretation of *P. nivalis* is correct, it is obviously out of place in the genus *Pteromonas*, and must be referred to *Scotiella* as *S. nivalis* (Chod.), F. E. Fritsch. With the genus *Scotiella* it agrees in several respects, viz. the single chloroplast with a pyrenoid, the wings (*cf.* especially the optical section shown in Chodat's fig. 70, J, with my optical section of *Scotiella antarctica*, fig. 11), the behaviour of these wings at the two ends of the cell ("qui se

[1] Chodat, *Algues vertes de la Suisse*, Berne, 1902, pp. 145–146.

[2] Chodat describes the cells of *Pteromonas nivalis* as "ordinairement remplie d'une huile jaune-dorée" (p. 146), which may well correspond to the yellow fat observed in the individuals of the yellow snow. Wille ("Algologische Notizen, xi.–xiv.," *Nyt Magazin f. Naturvidenskab*, xli., 1903, p. 170), however, speaks of the contents of the cells being generally coloured almost quite red by hæmatochrome. This is interesting as indicating that one and the same snow form may exhibit different pigments in different localities.

[3] *Cf.* Wille, *loc. cit.*, p. 171.

[4] *Loc. cit.*

prolongent vers les extrémités en arête saillante," according to Chodat, p. 146; "An beiden Enden des Zellinhalts finden sich Vorsprünge . . . sicherlich nur dadurch entstanden, dass die Rippen der Membran etwas vorsprangen," according to Wille, pp. 169, 170; *cf.* also my fig. 23), and, lastly, the apparent formation of new individuals by subdivision of the cell-contents.[1]

(*f*) CHODATELLA BREVISPINA, n. sp. (Pl. I., figs. 25, 26; Pl. II., phots. 3, 5, *Ch*).

A very typical and rather abundant member[2] of the yellow snow flora is constituted by spiny ellipsoidal cells, which appear to belong to a new species of *Chodatella*, which may be styled *C. brevispina* (Pl. I., figs. 25, 26). The cells of this species are discoid and about 18 μ long and 12 μ broad, and are covered all over their surface with uniformly distributed spines. The latter are very short and, as a general rule, do not project beyond the surface for a distance greater than twice the thickness of the wall; they are mostly rather delicate, but occasionally individuals bearing coarser spines were to be found. All the spines on a given cell are generally of about the same length, although sometimes slight differences are noticeable. The cell-membrane is colourless, and consists of two well-marked portions,—a dark-looking outer (probably cuticular) layer and an inner much lighter layer. There appears to be a single chloroplast, although I do not feel certain of this; a pyrenoid was not observed. Large quantities of fat are almost always present in these cells. In the majority of cases two more or less rounded masses are found, one at each end of the cell and separated by a central mass of granular protoplasm in which a considerable amount of starch frequently occurs (Pl. I., fig. 26). Often one of these two fat-masses is considerably larger than the other, and occasionally only one large mass is present at one end of the cell. In some individuals, lastly, the fat predominates to such an extent that only a small amount of granular protoplasm can be distinguished, all the remaining part of the contents being obscured by the accumulation of fat (Pl. I., fig. 25).

The greatest difficulty in the way of a satisfactory determination of this form as a species of *Chodatella* lies in the absence of all reproductive stages. In *Chodatella*[3] reproduction is effected by subdivision of the cell-contents to form a number of new

[1] Wille (*loc. cit.*, p. 171) also suggests on the basis of his observations that it may become necessary to remove *P. nivalis* from the genus *Pteromonas*; this is based on his view that the ordinary winged cells are aplanospores (resting-cells), that reproduction is effected by small fusiform zoospores, and on the possibility of the cells containing several chloroplasts without pyrenoids (see *loc. cit.*, p. 169). It does not appear that the last of these observations is correct; the others have already been criticised above.

Wille suggests that the oval cells provided with longitudinal ridges, referred to by Lagerheim as having been found in red snow from Amsterdamö (Spitsbergen) (*cf.* footnote 1 on p. 109), were individuals of *P. nivalis*. As stated in the footnote on p. 109, I am of opinion that they may belong to the genus *Scotiella*, but it hardly seems likely that they represent *P. nivalis*. The rather vague description points more to a form like *Scotiella polyptera*.

Until we know more about the movement referred to by Chodat, it seems advisable to leave *P. nivalis* in its present genus.

[2] This form is much commoner than *Scotiella antarctica*, but owing to its smaller size not nearly so striking.

[3] E. Lemmermann, "Beitr. z. Kenntn. d. Planktonalgen," I., *Hedwigia*, xxxvii., 1898, p. 309. Chodat, *loc. cit.*, p. 191.

daughter-individuals, which often acquire the shape, spines, etc., characteristic of the mature form before leaving the mother-cell (autospore-development). The individuals of *Chodatella brevispina* were frequently found lying together in groups of four or more, and that may indicate formation from a common mother-individual, but no stages in the process were observed. In most other species of *Chodatella* the spines are very long, few in number, and mostly confined to the two ends of the cell; but there are two species (viz. *C. echidna* (Bohlin), Chod., and especially *C. armata*, Lemm.)[1] in which the spines are more evenly distributed and also of approximately equal length. No other species of *Chodatella*, however, bears spines all over its surface. In all the described species the spines are very much longer than in the Antarctic form, and for this reason the specific name "*brevispina*" is proposed for the latter. In his description of *C. ciliata* (Lagerh.), Lemm., Chodat[2] states that the cells are "souvent munies de quelques globules huileux polaires," so that the occurrence of fat has already been recorded in the genus. The species of *Chodatella*, lastly, have one (or more) chloroplasts with or without pyrenoids. On the whole, therefore, the Antarctic form fits fairly well into the genus *Chodatella*, and owing to its numerous short spines and abundant storage of fat is regarded as a distinct species.[3]

Before passing on to the consideration of other forms it may be well to point out that there is some resemblance between *Chodatella brevispina* and the aplanospores of *Chloromonas alpina*, Wille,[4] found by Wille in green snow in Norway. Wille himself[5] refers to the resemblance of these aplanospores to *Lagerheimia* (a closely allied genus, regarded by many authorities as not generically distinct from *Chodatella*), but found transitions seeming to connect these structures with the ordinary motile cells of *C. alpina*. As regards the resemblance between *C. brevispina* and these aplanospores (apart from similarity in shape and size), it is purely superficial; for the latter have coarse pointed spines attached to the cell-wall by a broad base, they contain many plano-convex chloroplasts, and, although occurring in the same kind of habitat (on snow), appear to harbour no fat. If Wille's interpretation of these structures is correct, there is a possibility of the individuals of *C. brevispina* being aplanospores of some allied form; inasmuch, however, as Wille's evidence for the connection of the spiny cells he describes with *C. alpina* is a little doubtful, it may be that the latter constitute a second species of *Chodatella* occurring in the snow flora.

(*g*) Oocystis lacustris, Chod., f. *nivalis*, n. f. (Pl. I., figs. 27, 28).

Side by side with *Chodatella brevispina*, but much rarer than the latter, there occurs another form, which shows many similarities (Pl. I., figs. 27, 28). The cells are of the

[1] Chodat, *loc. cit.*, p. 192; Migula, *loc. cit.*, p. 671, pl. 35, Q, fig. 6. As the Antarctic species is not a plankton-organism like most other species of the genus, the relative shortness of the spines is comprehensible.

[2] *Loc. cit.*, p. 192.

[3] A full diagnosis of *Chodatella brevispina* will be found on p. 124.

[4] *Cf.* Wille, "Algologische Notizen, xi.," *Nyt Magazin f. Naturvidenskab*, xli., 1903, p. 124, and pl. iii., figs. 32–33.

[5] *Loc. cit.*, p. 124.

same general shape and the cell-contents are often quite identical, there being two terminal globules of fat with intermediate granular protoplasm (fig. 27); a pyrenoid could not be made out. These cells, however, differ from those of *C. brevispina* in three prominent respects: they are always of smaller dimensions (length, 13–15 μ), they have a perfectly smooth, rather thin membrane devoid of spines, and the ends are commonly more or less pointed (fig. 27) and never rounded off to such a marked extent as is the case in *C. brevispina* (*cf.* even fig. 28 with figs. 25, 26). Were it not for the difference of shape and the absence of all intermediate stages, these cells might be regarded as young individuals of the latter; but as it is, this view is scarcely permissible. Similar though somewhat larger cells appear to have been observed by Lagerheim[1] in red snow from Mount Pichincha in Ecuador; he suggests that they may belong to some member of the Volvocineæ. It seems much more likely, however, that they represent a species of *Oocystis*. In one or two cases a considerable number (about sixteen) of these cells was observed lying within a common mucilaginous investment, which would point to some species like *Oocystis lacustris*, Chod., or *O. glœocystiformis*, Borge. There are further resemblances to *O. lacustris* in the pointed shape of the cell, in the (probably ?) single chloroplast, and in the occurrence of oil-drops in the latter species;[2] also in the very feeble thickening of the ends of the cells in *O. lacustris*,[3] a feature which is much more pronounced in other species of the genus. For these reasons I am inclined to regard the cells shown in figs. 27 and 28 as merely a form (f. *nivalis*) of *O. lacustris*, Chod., characterised by the prominent storage of fat;[4] the cells, which Lagerheim observed, may possibly belong to the same species.

(*h*) SPHÆROCYSTIS SCHROETERI, Chod., f. *nivalis*, n. f. (Pl. II., phot. 2, *S*).

In sample No. 3 of the yellow snow an organism (text fig. 1, F and G, p. 122) was very abundant, which seems to be referable to the genus *Sphærocystis* of Chodat.[5] This form consists of larger or smaller groups of round or oval cells (text fig. 1, F), green in colour and with granular contents, embedded in very soft mucilage, the outline of which is often irregular, but sometimes roughly circular (particularly in the case of the smaller colonies). The cells are separated by considerable intervals from one another, and mostly show a very uniform distribution (text fig. 1, F); the intervening mucilage is quite structureless and invisible. Each cell has a delicate bounding membrane of its

[1] Lagerheim, "Schneeflora des Pichincha," *Ber. Deutsch. Bot. Ges.*, x., 1892, p. 525, footnote 2: "Zahlreiche ovale Zellen, 6–10 μ dick und 10–20 μ lang, welche grunen Inhalt und an den Enden je einen zuweilen rothlichen Œltropfen fuhrten. Sie lagen immer isoliert und konnten nicht zur Entwickelung gebracht werden."

[2] *Cf.* Chodat, "Etudes de Biologie lacustre," *Bull. Herbier Boissier*, v., 1897, p. 296; also *Algues vertes de la Suisse*, Berne, 1902, p. 190, fig. 105.

[3] Chodat's figures in most cases give very little indication of this thickening, which was not to be found in the Antarctic specimens. The latter may possibly have been relatively young individuals, a view which is supported by the thinness of the walls.

[4] See also p. 124.

[5] Chodat, "Etudes de Biologie lacustre," *Bull. Herbier Boissier*, v., 1897, pp. 292–295, pl. ix.; also *Algues vertes de la Suisse*, Berne, 1902, pp. 114, 115, fig. 53. According to G. S. West (*Journ. Linn. Soc., Bot.*, xxxix., 1909, pp. 75, 76) *Sphærocystis schroeteri*, Chod., and *Tetraspora lacustris*, Lemm., are synonymous (*cf.* also Chodat, *Alg. vertes*, p. 115).

own; the shape of the cells is mostly spherical, but sometimes slightly oval, and a kind of colourless beak is often to be seen on one side. In a few cases, especially after staining with iodine or gentian violet, it appeared as though there were a pair of short cilia arising from this beak and attached close together. All attempts to obtain clearer preparations were, however, unsuccessful, and the presence of cilia in the Antarctic form must therefore remain doubtful. I have been able to make out only very little of the cell-contents; a small round body (probably a pyrenoid) can generally be detected, and there was commonly a small colourless area beneath the beak at the front end of the cell, but the chloroplast could not be properly deciphered. The cell-contents frequently contain starch, but fat was generally completely absent in these colonies. Apart from the normal colonies just described, two other kinds of colonies were observed. Firstly, such as showed many or all of the cells in process of bipartition; and, secondly, colonies in which most or all of the cells had their contents divided up into a considerable number of smaller cells (generally about eight). The latter have a very characteristic appearance (fig. 1, G), and are on the whole commoner than the other two types. The small cells in these colonies are often distinctly ovoid and pointed at one end. They are generally more or less filled with the all-pervading fat, which appears to arise in the cells of the normal colony at the time of their division; for whereas the cells of the normal colony are, as above mentioned, quite devoid of fat, occasional colonies are to be found in which the cells contain considerable quantities of fat, and in these one or other of the cells are always in process of division.

The genus *Sphærocystis* was described by Chodat[1] in 1897; subsequently Wille[2] endeavoured to identify *S. schroeteri*, Chod., with *Glœococcus mucosus*, A. Br.,[3] a view that was opposed by Chodat in a later paper,[4] mainly on the grounds of the marked difference in size of the colonies in the two genera and the absence of cilia in his form. There seems, however, to be some evidence for the synonymy of the two genera, although the species are not necessarily identical; for the present they are probably best kept distinct. Chodat failed to observe the cilia on the cells embedded in mucilage, stating definitely "pas de pseudo-cils"; Wille does not say whether he observed them, although, as he makes no negative statement, it is to be presumed that he did.[5] Wille[6] describes as especially characteristic a clear space having the shape

[1] Chodat, *loc. cit.*

[2] Wille, "Algologische Notizen, xii., Über *Glœococcus mucosus*, A. Br.," *Nyt Magazin f. Naturvidenskab*, xli., 1903, pp. 163–166.

[3] *Cf.* A. Braun, *Betrachtungen über die Erscheinung der Verjüngung in der Natur*, Leipzig, 1851, p. 169 (Eng. trans. by A. Henfrey, 1853, p. 159); also A. Braun, "Über *Chytridium*, etc.," *Abhandl. Kgl. Ak. d. Wiss.*, Berlin, 1855, pl. v., figs. 5–20.

[4] "Quelques points de nomenclature algologique: I. *Sphærocystis*, Chod. ou *Glœococcus*, A. Braun?" *Bull. Herbier Boissier*, 2nd ser., iv., 1904, p. 233.

[5] There is also no mention of the cilia in Wille's description of *Glœococcus* in Engler-Prantl, *Die Natürl. Pflanzenfam.*, Nachtr. z. 1 Teil, 2 Abteil., Leipzig, 1909, p. 18.

[6] Wille, "Algologische Notizen, xii.," *loc. cit.*, p. 165. This space is here, probably as a result of a misprint, described as occurring in the back part of the cell ("im hinteren Teile der Zelle"). *Cf.* however fig. 5, A (p. 19), in Engler-Prantl, *loc. cit.*

of an inverted funnel ("verkehrt trichterförmiger Raum") at the front end of the cell. This, I believe, coincides with the colourless area beneath the beak in the cells of the yellow snow form, although my material was not sufficiently well preserved to enable me to make out its exact shape. Apart from this, however, the Antarctic form agrees also in other respects with the descriptions of A. Braun, Chodat, and Wille. Chodat's fig. 53, B (*Algues vertes de la Suisse*) very much resembles the normal colonies above described, although all the cells were generally not as spherical as his figure shows them.[1] His fig. 53, D (*cf.* also Wille, in Engler-Prantl, *loc. cit.*, fig. 5, D) shows a similar subdivision of the cell-contents into a number of small parts, as in text fig. 1, G (p. 122); in my material, however, the membrane of the mother-cell always remained intact till division was complete,[2] and the *Schizochlamys*-like stages figured and described by Chodat were not observed. The most noticeable points of difference between the yellow snow form and Braun's and Wille's *Glœococcus* lie in the small size of the colonies and possibly in the shortness of the cilia, which are stated to be very long in the latter form, although those which I believe to have observed were invariably rather short.

There can be no doubt that the three types of colonies found in the yellow snow material and above described belong to one and the same form, as numerous connecting-links were observed. Rather rarely isolated cells of the *Chlamydomonas*-type were met with in the material; some of these certainly belong to species of *Chlamydomonas* (*cf.* p. 118), but others may well be single swarmers of the *Sphærocystis*-colonies. Occasionally one finds more or less rounded granular cells with a wide envelope of delicate mucilage around the very delicate cell-wall; these cells agree in all respects with those of a normal colony, and it seems very probable that such stages constitute the commencement of a new colony. I have, however, been unable to demonstrate cilia in these cells.

The chief differences between *Sphærocystis schroeteri*, Chod., and *Glœococcus mucosus*, A. Br., on the one hand, and the yellow snow form on the other, may be summarised as follows:—(1) The colonies of the latter are frequently rather more irregular in shape than those of the former; (2) the cilia, if present, are much shorter; (3) the cells are of somewhat smaller dimensions and more frequently oval in shape; (4) *Schizochlamys*-like stages have not been observed; (5) the storage of fat. As I cannot feel certain of the occurrence of cilia in the yellow snow form, it will be best referred for the present to *Sphærocystis schroeteri*, Chod., as a forma *nivalis*.[3] It is of considerable interest that so abundant a plankton-form as *Sphærocystis* should form an important constituent of the yellow snow flora.

[1] An oval cell is, however, shown in the lower part of the colony.

[2] In one or two cases the membrane of the mother-cell was pronouncedly thickened, appearing gelatinous and stratified.

[3] *Cf.* p. 123.

(*i*) Trochiscia antarctica, n. sp. (Pl. I., fig. 30).

I have already referred to the abundant occurrence of species of *Trochiscia* in the material from the South Orkneys; one of them is characteristic for the yellow snow flora (Pl. I., fig. 30), although not particularly common. It consists of isolated spherical cells with a thick and rather gelatinous-looking wall, which is uniformly covered with small processes. The latter have typically the shape of truncated wedges with the truncated surface outermost, so that the cell presents the appearance of a cogged wheel. There is, however, considerable variety in the degree of differentiation of these processes, all transitions having been found from cells in which the processes are but feebly indicated (probably young daughter-cells?) to such as have very prominent processes; in the latter case they are often of slightly unequal length. The processes appear to be interconnected by a network of ridges. The cell-contents were always a little contracted; they appeared granular and often showed a well-marked central pyrenoid. Starch is always present, but fat is rare in this form, although now and again cells were found with quite a large quantity of it.

This species of *Trochiscia* appears to show some resemblance to *T. halophila*, Hansg., and *T. reticularis* (Reinsch), Hansg.,[1] but both these species have larger cells, and there are differences in the character of the membrane. The yellow snow form may provisionally be regarded as a distinct species, *T. antarctica*, n. sp., characterised by the peculiarly shaped processes on the membrane, the thick walls, and the faculty of fat-storage.[2] Attention may, however, be drawn to the similarity between this form and the zygospores of two species of *Chlamydomonas*, viz. *C. nivalis* (Sommerf.), Wille,[3] and *C. globulosa*, Perty;[4] especially in the latter case there is some considerable resemblance. The character of the contents of *Trochiscia antarctica* was, however, not at all like that of a zygospore, since as a general rule no great quantity of food-reserves was present; and nothing to indicate any relation to a species of *Chlamydomonas* was observed in the material. In fact, *T. antarctica* presents more the appearance of an independent alga than many other species of the genus do.

(*j*) Raphidonema nivale, Lagerh. (Pl. I., figs. 32, 33).

A not uncommon member of the yellow snow flora consists of short filaments of three or four (but occasionally many) cells running to a point at one or both ends (Pl. I., figs. 32, 33). The cells are provided with a very thin membrane, and contain but a single chloroplast without a pyrenoid. The filaments were generally more or less curved (fig. 33), and when only one end was pointed the other was rounded off (fig. 32). These filaments are undoubtedly referable to Lagerheim's genus *Raphidonema*.[5] He observed

[1] Hansgirg, *Prodromus d. Algenflora v. Böhmen*, ii., Prague, 1892, pp. 240, 241.

[2] A full diagnosis of *Trochiscia antarctica* will be found on p. 123.

[3] Wille, "Algologische Notizen, ix.–xiv.," *Nyt Magazin f. Naturvidenskab*, xli., 1903, pl. iii., fig. 45.

[4] *Cf.* Chodat, *Algues vertes de la Suisse*, Berne, 1902, p. 132, fig. 60, D.

[5] Lagerheim, "Schneeflora des Pichincha," *Ber. Deutsch. Bot. Ges.*, x., 1892, p. 523, and pl. xxviii., figs. 15–21.

vegetative reproduction of this form, the threads breaking into two halves, each of which has at first one pointed and one rounded end. The stage shown in my fig. 32 undoubtedly shows one of the products of such a division. Subsequently, according to Lagerheim, the round end grows out into a new hair-like point. Most of the individuals found in the yellow snow were of narrower dimensions than Lagerheim's form, and the cells were rather longer (fig. 33); but filaments were found here and there quite agreeing with *Raphidonema nivale*, Lagerh., and there is no reason to regard the forms in the yellow snow as distinct from this species.

In his recent revision of the green algæ Wille[1] includes Lagerheim's *Raphidonema* in the genus *Raphidium*, Kütz. (=*Ankistrodesmus*, Corda); this is in agreement with Chodat's earlier view.[2] It seems a little questionable, however, whether this is really warranted. The typical species of the genus *Raphidium* are unicellular or colonial forms, in which reproduction is effected by transverse division of the contents (frequently into four), followed by elongation of the segments, so that they ultimately come to lie side by side as a number of daughter-individuals within the mother-cell (so-called autospore-development). This has not been observed in *Raphidonema nivale*. On the other hand, although septate *Raphidiums* have been described (e.g. *R. pyrenogerum*, Chod., and *R. nivale*, Chod.[3]), the breaking up of the septate individual into two parts by fragmentation is not known for this genus. The resemblance of *Raphidonema* to *Raphidium* therefore appears to be purely superficial, and one must agree with Lagerheim's original view,[4] which regarded this snow alga as a member of the Ulotrichales, probably to be included in the Chætophoraceæ; the peculiar method of vegetative reproduction may, however, indicate a relationship to *Stichococcus*,[5] and until more is known about *Raphidonema* its exact position must remain doubtful.

Very rarely forms were found of the type shown in Pl. I., fig. 34. This shows a single cell of the *Raphidium*-type (diam. 2 μ) with a prominent central pyrenoid. This is probably a species of *Raphidium*, possibly *R. pyrenogerum*, Chod., which is distinguished by having a pyrenoid, but Chodat's species appears to be much broader. I have seen too few individuals to be sure of the specific determination.

Filamentous forms are poorly represented in the yellow snow flora. The most abundant is *Ulothrix subtilis*, Kütz., of which relatively short filaments were always to be found embedded among the numerous unicellular and colonial constituents (Pl. II., phots. 1, 2, *U*). Next in abundance comes *R. nivale*, Lagerh., which has already been considered. Lastly, very occasional filaments of a broad species of *Œdogonium* (diam. cell = 20 μ) with well-marked caps were observed.

[1] Wille, in Engler-Prantl, *Die Natürl. Pflanzenfam.*, Nachtr. z. 1 Teil, 2 Abteil., 1909, p. 68.

[2] Chodat, "Flore des neiges du col des Ecandies," *Bull. Herbier Boissier*, iv., 1896, p. 886. It does not seem that Chodat's *Raphidium nivale* is in any way allied to *Raphidonema*.

[3] Chodat, *Algues vertes de la Suisse*, Berne, 1902, p. 200, fig. 120.

[4] *Loc. cit.*, p. 523.

[5] *Cf.* Lagerheim, *loc. cit.*, pp. 523, 524.

The remaining algæ found in the yellow snow are very rare. These include forms like *Pleurococcus vulgaris*, Menegh., *Mesotænium endlicherianum*, Naeg., *Chlamydomonas caudata*, Wille, *Nostoc minutissimum*, Kütz., and probably other species of *Chlamydomonas*. Lastly, mention must be made of large round cells with a smooth and fairly thick membrane, and filled with yellowish-red or reddish, homogeneous or somewhat granular contents (text fig. 1, D, p. 122); the contents were commonly slightly contracted away from the wall on one side of the cell. These cells are of large size (diam. = about 40–60 μ)—often as big as or bigger than the largest *Chlorosphæra*-cells—and although rare are very easily recognised when present, owing to their distinctive colour. These cells rather recall some figured by Wittrock,[1] and referred by him to *Chlamydomonas* (*Sphærella*) *nivalis* (Sommerf.), Wille, but owing to their large size (about 52 μ) it may be doubted whether they really belong to this species. Except for their larger size, there is also some resemblance to the resting-cells of *C. sanguinea*, Lagerh.[2]

In sample No. 2 a fungus was frequently to be found which, judging by its gonidiophore, was a species of *Penicillium*. A second fungus occurred in the other two samples, but could not be determined.[3]

In concluding this consideration of the yellow snow flora, attention may be drawn to one or two general features. The flora is practically entirely composed of green algæ (except for the above-mentioned species of *Nostoc*). Diatoms are represented only by fragments of frustules, and there are very few even of these. The plankton character of the whole flora is also a point of interest, and indicates that it may have arisen in part by spores of plankton-forms being carried by the wind on to the surface of the snow. This probably applies to all snow floras.

C. RED SNOW.[4]

The three samples (Nos. 4–6) of red snow included in the collections from the South Orkneys were all of them very poor in algal forms, showing that red snow in

[1] V. B. Wittrock, "Om snons och isens Flora, etc.," in A. E. Nordenskiold, *Studier och forskningar*, etc., Stockholm, 1883, pl. iii., fig. 2.

[2] Lagerheim, *loc. cit.*, pl. xxviii., fig. 1. It having been suggested to me that the cells above described might be cysts of rotifers, I sent some material of yellow snow to Mr James Murray, who very kindly informs me that the cells in question are quite unknown to him and not rotifers. On the same authority I am able to state that the yellow snow includes yellow cysts (100–150 μ) of bdelloid rotifers and a species of *Collembola*.

[3] Tufts of short threads, richly branched in an arborescent manner and composed of spindle-shaped cells, 1 μ or less in diameter. Cells thickest at a point about two-thirds of their length from the base; from this point they taper gradually towards the base and rapidly towards the apex of each cell.

[4] So many accounts of red snow have already been published, that a general consideration seemed unnecessary, and the following account deals solely with the components of the samples of red snow from the South Orkneys. The most important contributions on the subject of red snow are: V. B. Wittrock, "Om snons och isens Flora, etc.," in Nordenskiold, *Studier och forskningar*, Stockholm, 1883, pp. 65–123, and pl. iii.; Lagerheim, "Bidrag till kannedomen om snofloran i Lulea Lappmark," *Bot. Notiser*, 1883; Lagerheim, "Die Schneeflora des Pichincha," *Ber. Deutsch. Bot. Ges.*, x., 1892, pp. 517–534, pl. xxviii.; Lagerheim, "Ein Beitrag zur Schneeflora Spitzbergens," *Nuova Notarisia*, 1894; Chodat, "Flore des neiges du col des Ecandies," *Bull. Herbier Boissier*, iv., 1896, p. 881 *et seq.* and pl. ix.; Chodat, *Algues vertes de la Suisse*, Berne, 1902, pp. 95, 96.

this region does not attain to nearly so abundant a development as yellow snow.[1] The number of species present is also smaller. On the whole sample 4 was richer in individuals than either 5 or 6, and showed a somewhat different constitution. Nearly all the forms present were in the resting condition, so that some doubt attaches to certain determinations. The samples of red snow included a good deal of non-algal matter, such as hairs, starch grains, pollen grains of *Podocarpus*, etc.

In comparison with the flora of the yellow snow we have to note certain similarities and certain differences. Among the former we may reckon the occurrence of characteristic forms of the yellow snow flora, such as *Scotiella antarctica*, F. E. Fritsch, and *Raphidonema nivale*, Lagerh. The former was found only in samples 5 and 6, especially in the latter; the number of individuals was small, but those present were of exceptionally large size (length of cell about 55 μ). They appeared to contain the same yellowish fat as in the yellow snow forms; no resting-stages were observed. The *Raphidonema* was quite common (especially in sample 4), and in this case agreed absolutely with Lagerheim's description. Apart from fragments of an *Œdogonium* it was the only filamentous form present.

There are two marked differences from the yellow snow flora. These are (*a*) the immense preponderance of red spherical cells, no doubt constituting the resting-cells of different members of Chlamydomonadaceæ (see below), and (*b*) the occurrence of various diatoms in all three samples. The resting-cells are of two chief types, viz. with and without a broad mucilage-sheath. The latter type are circular, with a smooth, somewhat thickened membrane and granular contents, with a central pyrenoid (text fig. 1, A, p.122); the diameter of these cells varies between 10 and 20 μ. The red colouring matter in the contents had been for the greater part taken up into the preserving fluid, and the cell-contents appeared colourless or slightly greenish; it is therefore impossible to say what the exact colour of these cells was in nature. A considerable quantity of fat was often present in these resting-cells. They recall very markedly the resting-cells (aplanospores) of *Chlamydomonas nivalis* (Sommerf.), Wille (=*Sphærella nivalis*, Sommerf.), as figured by Wittrock.[2] As very few other stages of this alga were found, the determination must, however, remain somewhat doubtful. In one or two cases subdivision of the contents into a number of parts was observed, but this, of course, scarcely aids in determining the species.

The second type of resting-cell (observed only in sample 4) closely resembles the other type except that the cells are surrounded by a broad sheath of mucilage often about two to three times the width of the cell in diameter (*cf.* text fig. 1, C, p. 122[3]); in many cases the mucilage was of a deep red colour, probably owing to the colouring matter of the cell having diffused out and stained the mucilage under the influence of the preserv-

[1] *Cf.* also the remarks on the distribution of red and yellow snow cited on p. 99, from Dr R. N. Rudmose Brown's letters.

[2] Wittrock, *loc. cit.*, tab. iii., fig. 1.

[3] The mucilage-sheath was often considerably broader than is shown in this figure.

ing fluid. This deeply-coloured mucilage made details of the enclosed cell difficult to determine, but so much could be seen that it has a moderately thickened wall and granular contents; a pyrenoid (?) was only very rarely visible. Numerous small particles were generally adhering to the surface of the mucilage, and this still further obscured the enclosed cell. The resting-cells of the second type were far less numerous than those of the first. They appear to correspond to cells observed by Lagerheim,[1] and referred by him to *Chlamydomonas*, sp.; similar cells were noticed by Wittrock.[2] I am unable to add to our knowledge of these cells, and have consequently merely described them in the systematic portion of this paper as *Chlamydomonas*, sp. (?). Inasmuch as these cells are of about the same dimensions as the smaller resting-cells of the first type (described above), and as the two kinds of cells occur side by side, they may be merely different stages of the same organism.

Apart from the forms hitherto mentioned, the only other constituents of the red snow from the South Orkneys are diatoms, which are, however, found only as isolated individuals (*Melosira sol*, Kütz., *Coscinodiscus radiatus*, Ehrb., etc.). It seems probable that only the red resting-cells above described and the *Raphidonema* are true components of this flora, and that the remaining forms are introduced by the agency of wind and (?) animals (possibly the penguins). The *Scotiella* is perhaps an introduction from the yellow snow flora (which is sometimes not very far separated from the red snow, *cf.* p. 99), while the diatoms (which are in great part marine forms) probably come from the seashore.

The complete list of algæ found in the red snow from the South Orkneys is as follows:—

Chlamydomonas nivalis (Sommerf.), Wille (?).
,, sp. (*cf.* above).
Scotiella antarctica, F. E. Fritsch.
Raphidonema nivale, Lagerh.
Œdogonium, sp.
Zygnema, sp. (one filament).
Melosira sol, Kütz.
Coscinodiscus radiatus, Ehrb.
Navicula borealis (Erhb.), Kütz.
Amphora ovalis, Kütz.
Triceratium, sp. (*T. arcticum*, Bright?).

D. SYSTEMATIC ENUMERATION OF FRESHWATER ALGÆ FROM THE SOUTH ORKNEYS.

A. ISOKONTÆ.

CHLAMYDOMONADACEÆ.

1. Chlamydomonas caudata, *Wille, Algol. Not.*, xi., *Nyt Magazin f. Naturvidenskab*, xli., 1903, pp. 115–118 and 135–136, pl. iii., figs. 4–11 (Pl. I., figs. 35–40).

Samples 10 and 11, abundant; also as a rare form in the yellow snow.

This and the following species are the only forms found in the material from the South

[1] Lagerheim, *Ber. Deutsch. Bot. Ges.*, x., 1892, pp. 523, 529, pl. xxviii., fig. 10.
[2] Wittrock, "Om snöns och isens Flora," *loc. cit.*

Orkneys that were obviously preserved in an active, motile condition. The prominent features of this species, as described by Wille, are the protrusion of the posterior end of the individual into a conical tip (figs. 37, 38), which is often somewhat bent to one side (fig. 36), the fact that the two cilia are about equal in length to the body of the cell, and that the strongly thickened base of the chloroplast contains a median rounded pyrenoid (figs. 37, 38). There can be no doubt that the individuals observed belong to this species, although one or two minor points of difference were noted. The cilia were frequently found to be as much as one and a third times the length of the cell (not shown in the figures); they were nearly always curved back or spread out at right angles to the body of the cell (figs. 37, 38), as Wille shows them. The size of the ordinary individuals varies considerably; length = 13–20 μ, breadth = 7–10 μ, but some of the dividing individuals are much larger. The pointed posterior end, as a general rule, lies in the same straight line as the axis of the individual, but bending was not uncommon. The cell-membrane is almost invariably much more prominently thickened at the pointed posterior end, and not uncommonly individuals are found in which the whole of the pointed portion consists of solid membrane (fig. 39). In many cases (*cf.* Wille, *loc. cit.*) the posterior part of the protoplasmic contents is also pointed and in the living individual probably in direct contact with the pointed cell-wall, although in preserved material generally separated from it by a space (*cf.* however fig. 38). But in a considerable number of individuals, the back end of the protoplasmic body was rounded off and separated by a marked interval from the pointed tip; it seems that this may be a preliminary to cell-division, as all dividing individuals were found to have the protoplast rounded off in this way (*cf.* fig. 35). Many examples of division (from the presence of two pyrenoids in the cell up to the formation of two daughter-individuals, fig. 35) were observed; in all cases such divisions were longitudinal and took place after withdrawal of the cilia. Curious division-stages were found in the form of very large individuals (in this case with or without cilia) containing a considerable number (eight or more) of protoplasmic units, each with a pyrenoid (fig. 36); such individuals may possibly have been forming gametes. The prominent beak at the point of origin of the cilia, described and figured by Wille, was often difficult to recognise. On the other hand, in a few cases there was a very pronounced development of this beak (fig. 40) in the form of a rounded protrusion, from the base of which the cilia arose. Apart from these peculiarities, the Antarctic form showed all the features described by Wille, viz. ribbing of the basin-shaped chloroplast, an elongated stigma (rarely visible), contractile vacuoles, etc.

2. CHLAMYDOMONAS EHRENBERGII, *Gorosch.*, *Bull. Soc. imp. d. Nat. de Moscou*, 1890, No. 3, p. 128–131, pl. iii., figs. 10–25.

Samples 10 and 11, common.

Probable zygospores observed in sample 11.

3. ? CHLAMYDOMONAS INTERMEDIA, *Chod.*, *Alg. Suisse*, 1902, p. 135.

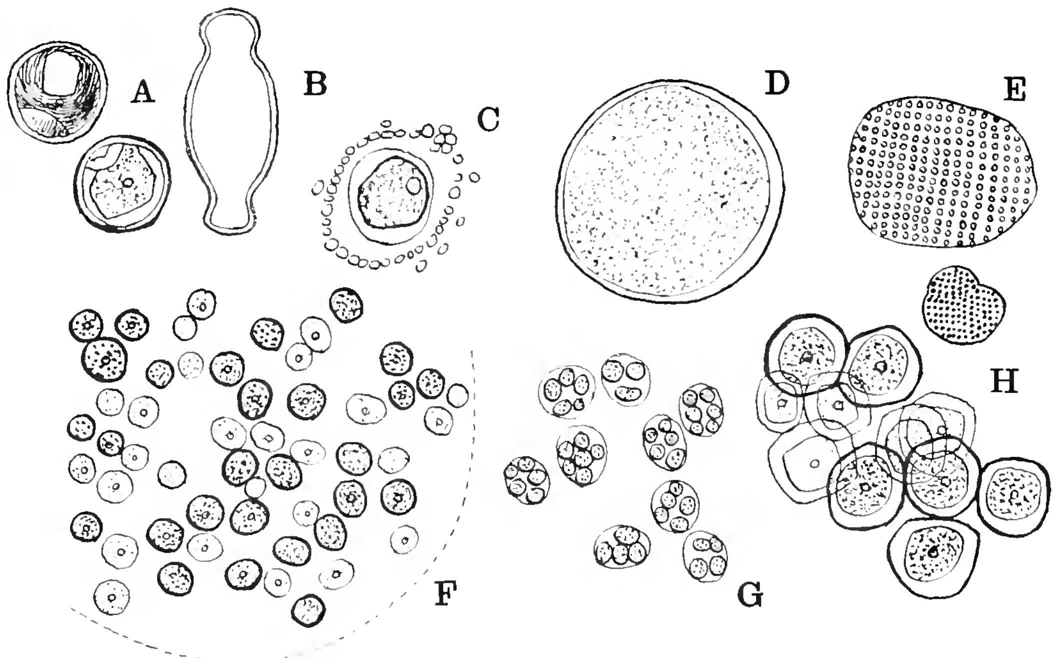
Samples 10 and 11, rather common.

I am somewhat doubtful about the determination of this form.

4. CHLAMYDOMONAS NIVALIS (*Sommerf.*), *Wille*, *Algol. Notizen*, xi., *Nyt Magazin f. Naturvidenskab*, xli., 1903, pp. 147–148 (text fig. 1, A).

Samples 4–6 (red snow !), common.

Cf. description on p. 119; as suggested by Chodat, Wille, etc., these resting-cells may include Lagerheim's *C. sanguinea*. Diam. of resting-cells = 10–20 μ.



TEXT FIGURE 1.

A, *Chlamydomonas nivalis* (Sommerf.), Wille, resting-cells from the red snow ($\times$1100); B, *Navicula muticopsis*, V. Heurck, outline of an individual from sample 11 to show shape ($\times$1030); C, *Chlamydomonas*, sp., resting-cells from the red snow (*cf.* p. 119) ($\times$1100); D, resting-cells from the yellow snow (*cf.* p. 118) ($\times$830); E, upper figure, *Microcystis merismopedioides*, n. sp., surface-view of colony (*cf.* p. 130) ($\times$1100); lower figure, typical colony of the same ($\times$540); F, *Sphærocystis schroeteri*, Chod., f. *nivalis*, n. f. from the yellow snow ($\times$540); G, the same, showing division of cells of colony ($\times$830); H, *Cœlastrum microporum*, Naeg., f. *irregulare*, n. f. (*cf.* p. 126) ($\times$1100).

5. CHLAMYDOMONAS, sp. (text fig. 1, C).

Sample 4 (red snow !), rather common.

Resting-cells in a wide sheath of mucilage; diam. of cell alone = 9–10 μ; of cell and mucilage = 20–28 μ (see also pp. 119–120).

PHACOTACEÆ.

6. PTEROMONAS NIVALIS (*Shuttelw.*), *Chod.*, *Alg. Suisse*, 1902, p. 145, fig. 70; Wille, *Algol. Notizen*, xiii., *Nyt Magazin f. Naturvidenskab*, xli., 1903, p. 167–171, pl. iii., figs. 46–51 (Pl. I., figs. 22–24 and 31).

Samples 1–3 (yellow snow !), isolated.

This species should probably be transferred to the genus *Scotiella* (*cf.* pp. 109–111). Length of individuals = 22 μ; breadth = 12 μ.

TETRASPORACEÆ.

7. Sphærocystis schroeteri, *Chod.*, *Bull. Herbier Boissier*, v., 1897, p. 296, pl. ix.

Forma *nivalis*, n. f. (text fig. 1, F–G; Pl. II., phot. 2, *S* (*cf.* pp. 113–115)).

Familiæ microscopicæ forma paulo irregulariore quam in specie typica; cellulæ ante divisionem reservant abundantiam adipis, qui invenitur in cellulis filialibus; cellulæ sunt sæpe ellipsoideæ. Diam. cell. = 7–12 μ; diam. cell. fil. = 2–3 μ.

Samples 1 and 3, especially common in the latter.

PROTOCOCCACEÆ.

8. Chlorosphæra antarctica, n. sp. (Pl. I., figs. 2–6; Pl. II., phots. 1, 3, 5, 6, *C*).

Cellulæ aut magnæ sphæricæ singulæ aut parvæ, paulum angulares, in familias parvas consociatæ; cellulæ magnæ et interdum cellulæ parvæ vagina mucosa ampla munitæ; membrana modice incrassata, plerumque præbentes duo strata; chromatophora fere sphærica cum foramine parvo in una parte; adeps semper adest abundans in cellulis; paucæ granulæ amylaceae plerumque adsunt. Propagatio per divisionem; zoosporas non inveni. Diam. max. cellulæ magnæ = 43 μ; diam. min. cell. parvæ = 7 μ (omnes transitiones inter duas dimensiones); diam. cell. plerumque = 11 μ–26 μ; diam. vaginæ mucosæ = 39–50 μ (cell. pertinentes = 26–28 μ).

Probably nearly allied to *C. angulosa*, Klebs. (*cf.* p. 104).

Samples 1–3 (yellow snow !), very abundant.

For full consideration, see pp. 103–104.

9. Trochiscia hystrix (*Reinsch*), *Hansg.*, *Hedwigia*, 1888, p. 129; *Reinsch*, Über *Acanthococcus*, *Ber. Deutsch. Bot. Ges.*, 1886, p. 241, tab. xi., fig. 25.

Sample 10, rare; previously recorded from South Georgia (Reinsch).

10. Trochiscia reticularis (*Reinsch*), *Hansg.*, *Prodr. Algenflora v. Böhmen*, ii., 1892, p. 241.

Sample 10, rather common.

A small form of this species; diam. cell. = 10 μ.

11. Trochiscia antarctica, n. sp. (Pl. I., fig. 30).

Cellulæ sphæricæ solitariæ cum membrana crassa gelatinosa numerosis processibus cuneatis truncatis obtectæ et junctis reticulo costarum; chromatophoræ ?; cellulæ cum cytoplasmate granuloso, semper granulas amylaceas et interdum aliquantum adipis includente. Propagatio ? Diam. cell. = 10–13 μ; crassitudo membranæ = 2–3 μ.

Samples 1–3 (yellow snow !), fairly common.

Probably nearly allied to *T. reticularis* (Reinsch), Hansg. For full consideration, see p. 116.

12. Trochiscia nivalis, *Lagerh.*, *Ber. Deutsch. Bot. Ges.*, x., 1892, p. 530, and pl. xxviii., fig. 23 (Pl. I., fig. 29).

Sample 11, rare.

The individuals were rather smaller than those described by Lagerheim (diam. cell. = 10 μ), but as in his form covered with very numerous minute spines; one (or more ?) pyrenoids were visible in every case. There appear to be several chloroplasts.

13. Trochiscia pachyderma (*Reinsch*), *Hansg.*, *Hedwigia*, 1888, p. 128; *Reinsch*, Über *Acanthococcus*, *Ber. Deutsch. Bot. Ges.*, 1886, p. 240, tab. xi., figs. 8–9.

Samples 10 and 11, fairly common.

SCENEDESMACEÆ (sensu Oltmanns).

14. Oocystis lacustris, *Chod.*, *Bull. Herbier Boissier*, v., 1897, p. 296, and pl. x., fig. 1–7.

Forma *nivalis*, n. f. (Pl. I., figs. 27, 28).

Poli cellularum rotundati vel acuti; in cellula aliquantum adipis flavi. Long. cell. = 13–15 μ; lat. cell. = 9–10 μ.

Samples 1–3 (yellow snow !), rare.

This form has been fully considered on pp. 112–113.

15. Oocystis solitaria, *Wittr. in Wittrock et Nordstedt*, "Alg. aquæ dulc. exsicc," No. 244, *Bot. Notiser*, 1879, p. 24 and fig.

Sample 11, rare.

Cells ellipsoidal in shape, with rounded ends; membrane moderately thick, with apparently two layers, slightly thicker at the two ends of the cell; cells generally solitary, but now and again to the number of about eight within a mother-cell. Fat generally present in the cell-contents. Length of cells = 16–20 μ; width = 13 μ.

16. Chodatella brevispina, n. sp. (Pl. I., figs. 25, 26; Pl. II., phots. 3, 5, *Ch*).

Cellulæ ellipsoideæ plus minusve complanatæ setis brevibus quæ non amplius bis crassitudine membranæ cellulæ exstant per totam superficiem externam confertæ; setæ plerumque tenues et angustæ, interdum paulo crassiores, æquilongæ; inter ea quæ cellula continet semper est adeps, plerumque abundans, sæpe similis duobus globis in utroque fine cellulæ. Long. cell. = 17–20 μ; lat. cell. = 10–15 μ.

Samples 1 and 3 (yellow snow !), common; isolated in sample 10.

This species differs from all hitherto described species of *Chodatella* in having very short spines, which cover the surface uniformly. A full consideration will be found on pp. 111–112.

SCOTIELLA, nov. gen.

Cellulæ ellipsoideæ in utroque fine rotundatæ processibus alæformibus plus minusve longitudinalibus sex aut multis munitæ; alæ sunt aut rectæ aut undulatæ; chromatophoram singularem esse probabile est, cum pyrenoide; abundantia est adipis in una specie. Propagatio subdivisione cellulæ immutatæ aut sporæ perdurantis in paucas partes verisimile est. Sporæ perdurantes cum membranis valde incrassatis transfiguratione cellularum vulgarium formari videntur.

This genus is certainly a close ally of *Oocystis* (*cf.* p. 108). I think it very probable that *Pteromonas nivalis* (Shuttlw.), Chod., is a species of this genus (*cf.* p. 110).

17. SCOTIELLA ANTARCTICA, n. sp. (Pl. I., figs. 7–17 ; Pl. II., phots. 1, 4, 6, *Sc*).

Cellulæ ellipsoideæ circiter duplo longiores quam sunt latæ sex e pariete exstantibus alæformibus processibus, qui extenduntur recti et æquidistantes inter duos fines cellulæ instructæ. Unus par alarum oppositarum (alæ principales) extenditur continuus circa cellulam ; duo alii pares alarum (alæ laterales) separati sunt alis principalibus, et ab utroque fine cellulæ paulum exstantes introrsum subito curvantur, ita ut in utroque fine cellulæ sinus formatus esse videatur (*cf.* fig. 8 et 9). Ala quæque habet mediam incisuram propriam speciei. Cellula continet multum adipis flaventis; cytoplasmatis structura investigari non potest. Sporæ perdurantes cum membrana crassa et undulata sunt formatæ metamorphosi cellularum vulgarium. Propagatio (?) subdivisione cellulæ immutatæ aut sporæ perdurantis in paucas partes possibile videtur. Long. cell. ab altero fine ad alterum = 43–49 μ (interdum 55 μ); lat. veri corporis cell. = 16–21 μ; lat. totius cell. (*i.e.* cum alis) = 28–30 μ (interdum 42 μ).

Samples 1–3 (yellow snow !), 5 and 6 (red snow !), 9, 11, and 15 ; rather common in yellow and red snow, rare in the other samples. Largest individuals in red snow.

A full description and consideration of this species will be found on pp. 105–108.

18. SCOTIELLA POLYPTERA, n. sp. (Pl. I., figs. 18–21).

Cellulæ late ellipsoideæ, paulo longiores quam sunt latæ, magno numero alarum multo minus exstantium quam in *S. antarctica* instructæ. Alæ plerumque sunt paulum directæ in spiram et undulatæ, ita ut adumbratio cellulæ videatur crenata ab omnibus partibus. Alæ exstant paulum ab utroque fine cellulæ et curvantur introrsum ita ut sinus debilis formetur. Adeps reservari non videtur. Sporæ perdurantes ? Propagatio subdivisione cellularum vulgarium probabilis est. Long. cell. = 20–24 μ ; lat. cell. = 16–17 μ.

Samples 1 and 3 (yellow snow !), very rare ; as an occasional form in samples 10, 11, and 15.

This species has been considered more fully on pp. 108–109.

19. ? RAPHIDIUM PYRENOGERUM, *Chod.*, *Algues vertes de la Suisse*, 1902, p. 200, fig. 119 (Pl. I., fig. 34).

Samples 1 and 3 (yellow snow !), rare.

Cf. p. 117. The forms observed are possibly referable to a distinct species, but the material was insufficient to come to definite conclusions on this point. Width of cells = 2 μ.

20. Cœlastrum microporum, *Naeg. ex. A. Br., Alg. unicell.*, 1885, p. 70; *Rabenh., Fl. Europ. Alg.*, iii., 1868, p. 80.

Samples 10, 11, and 15, fairly common.

Forma *irregulare*, n. f. (text fig. 1, H, p. 122).

Cellulæ cœnobii irregularissime cohærentes.

In sample 11 there occurred side by side with normal colonies of *C. microporum* others, in which the cells were very irregularly connected, so that the compact spherical appearance of the normal colony was often quite lost. Frequently the sphere was only half formed; in other cases, while several cells of the colony showed the usual arrangement, others were so disposed that they stood off from the general surface of the colony and completely destroyed the symmetrical character of the latter (fig. 1, H). In other cases again the colonies were very small, consisting of only four or six cells. These peculiar forms may possibly be explained by Senn's observations ("Über einige coloniebildende einzellige Algen," *Bot. Zeitung*, lvii., 1899), who found that colonies of *Cœlastrum* tend to dissociate into their individual cells if plenty of oxygen is present in the surrounding medium. This is likely to be the case in water in these Antarctic localities and may account for the numerous irregularities above described. Samples 10, 11, and 14 contained numerous isolated cells of the *Cœlastrum*-type, and these are very probably to be regarded as dissociation-products of normal colonies.

21. Cœlastrum sphæricum, *Naeg., Gatt. einzell. Algen*, Zürich, 1849, p. 98, and tab. v., c, fig. 1.

Sample 11, rather rare.

PLEUROCOCCACEÆ.

22. Pleurococcus vulgaris, *Menegh., Monograph. Nostoch.*, p. 38.

Samples 1 and 3 (yellow snow!), rare; samples 10 and 11, not uncommon.

This species was occasionally found in Nos. 10 and 11 forming short filaments.

23. Protoderma brownii, n. sp. (Pl. I., fig. 1; Pl. II., phots. 1, 2, 3, 5, *P*).

Thallus constat ex uno vel duobus (vel pluribus?) stratis cellularum et explanatus est in summa nive; margo thalli irregularis. Cellulæ multangulares vel angulis modice rotundatis; membranæ cellularum gelatinosæ (?), hyalinæ, lamellosæ, lamella intermedia paulum granulata. Chromatophora singula, similis disco arcuato, cum pyrenoide. Cellulæ interdum continent aliquantum adipis. Propagatio? Diam. cell. = 5–12 μ.

Samples 1 and 3 (yellow snow!), abundant.

It is probable that *Pleurococcus vulgaris*, Men. β *cohærens*, Wittr. ("Om snöns och isens Flora," *loc. cit.*), in part belongs to this species. Wittrock's fig. 17 (on pl. iii.) strongly recalls a patch of *Protoderma brownii.*

A full consideration of this species will be found on pp. 102–103. In sample 16 a very similar form was found growing on *Prasiola crispa*; the cells (diam. 5–7 μ), however, lacked fat, and the cell-walls were not nearly so gelatinous.

24. Eremosphæra viridis, *De Bary, Conj.*, p. 56, tab. viii., figs. 26–27; *Rabenh., Fl. Europ. Alg.*, iii., 1868, p. 24.

Sample 11.

Average diameter of cells = 50 μ.

ULOTRICHACEÆ.

25. Ulothrix subtilis, *Kütz., Spec. Alg.*, p. 345; *Tab. Phyc.*, ii., tab. 85; *Rabenh., Fl. Europ. Alg.*, iii., 1868, p. 365 (Pl. II., phots. 1, 2, 6, *U*).

Samples 1 and 3 (yellow snow!), rather rare.

CHÆTOPHORACEÆ.

26. Raphidonema nivale, *Lagerh., Ber. Deutsch. Bot. Ges.*, x., 1892, p. 523, pl. xxviii., figs. 15–21 (Pl. I., figs. 32, 33).

Samples 1–3 (yellow snow!), rather rare; 4–6 (red snow!), rather common.

Many of the filaments were narrower than Lagerheim's form; diam. of cells = 2–4 μ. See also pp. 116–117.

ŒDOGONIACEÆ.

27. Œdogonium, sp.

Samples 1 and 3 (yellow snow!), isolated.

Diam. of cells = 20 μ; length of cells = 56–65 μ; cells with numerous caps.

28. Œdogonium, sp.

Sample 4 (red snow!), isolated.

Diam. cell. = 8 μ; cells about three times as long as their diameter.

PRASIOLACEÆ.

29. Prasiola crispa (*Lightf.*), *Ag., Sp.*, p. 416; *Kütz., Tab. Phyc.*, v., tab. 40, fig. 6.

Samples 8, 9, 11, 12, and 16, abundant; numerous early stages in sample 16.

This form is already well known as occurring in Antarctic regions. It was first recorded by Hooker and Harvey (*Botany of the Antarctic Voyage* (*Flora Antarctica*), vol. ii., pp. 498–499), as *Ulva crispa*, Lightf., as occurring in "Berkeley Sound, Falkland Islands; on moist rocks; Cockburn Island, Graham's Land; very abundant." They add the comment: "A highly interesting species, because it is one of the very few terrestrial plants that have been gathered on the limits of vegetation both in the Northern and Southern hemisphere." Subsequently it was recorded by Hariot from Cape Horn, by Svedelius from Patagonia, and by Wille from Cape Adare ("Antarktische Algen. Mitteilungen über einige von C. E. Borchgrevink auf dem antarktischen Festlande gesammelte Pflanzen," *Nyt Magazin f. Naturvidenskab*, xl., 1902, pp. 209–219). Various authors, who have dealt with the Antarctic *Prasiolas*, have held rather different views as to the specific determinations; several (such as Kützing, Rabenhorst, and Svedelius) consider that there are two species, *Prasiola crispa* and *Prasiola antarctica*, Kütz.[1] These different views are fully considered in the paper of Wille above cited. On the basis of a careful investigation of Borchgrevink's material from Cape Adare, Wille (*loc. cit.*, p. 217) comes to the conclusion that there is no true point of difference between *P. antarctica* and *P. crispa*; it appears, however, that Borchgrevink's material was the true *P. crispa* and not the form described as *P. antarctica* by other authorities.

There appears to be no doubt that some of the Antarctic *Prasiola* is distinguished from the normal *P. crispa* by larger interspaces between the areolæ and prominent thickening of the outer walls of the cells, but it may be questioned whether they warrant the establishment of a distinct species. The differences do not appear to be of specific value, and the case would perhaps be best met by regarding the Antarctic type as a var. *antarctica* of *P. crispa*. No typical specimens of *P. antarctica* were present in the material from the South Orkneys.[2]

My material showed most of the stages figured by Wille on his pl. iii. Numerous filaments of the *Hormidium*-stage were observed, but in many of them a considerable number of the cells were dead or dying, and it appeared that the filaments were undergoing fragmentation without coming to anything further. Stages like those shown in Wille's figs. 13 and 14 were also not uncommon. Little detached groups of cells, like those of Wille's figs. 11 and 12 were very common in the sediment at the bottom of the tubes. It appears that such groups of cells are not necessarily formed only in the marginal portions of the thallus. In some specimens there were extensive strips of the thallus in which the cells were obviously in a moribund condition, and in the centre of such patches there was often a small rounded group of living cells with very abundant contents. The surrounding dying cells were of considerably larger dimensions than the others, and looked as though they had not divided recently. No doubt the central group of living cells becomes freed by the dying away of the surrounding part of the thallus, and acts as an organ of vegetative propagation.

The cells of the South Orkneys material had a curious purplish or olive-brown tinge, which is probably due to the action of the preservative (1 per cent. phenol); staining with iodine brought out the chloroplast and pyrenoid very plainly. The dimensions were as follows:—width of cells $= 4\,\mu$; length $= 6\,\mu$; thickness (*i.e.* dimensions at right angles to surface of thallus) $= 13\,\mu$. There was always only a single layer of cells.

[1] *Cf.* also W. and G. S. West, *Brit. Antarct. Exped., 1907–09*, vol. i., *Biology*, part vii., "Freshwater Algæ," 1911, p. 272–274.

[2] Since writing the report on the Algæ of the South Orkneys, which was published in the *Journ. Linn. Soc.*, I have examined the true *Prasiola antarctica*, and this has consequently led me to modify slightly my remarks on the two species given in the *Linn. Soc.* paper.

B. CONJUGATÆ.

MESOTÆNIACEÆ.

30. Mesotænium endlicherianum, *Naeg.*, *Gatt. einzell. Alg.*, 1849, p. 109, tab. 6, b; West and West, *Brit. Desm.*, 1904, p. 56, pl. iv., figs. 20, 21.

Sample 15, fairly common; samples 1 and 3 (yellow snow!), isolated.

There appeared to be more than two pyrenoids. Cells 24–26 μ long; 8–9 μ broad.

31. Cylindrocystis brébissonii, *Menegh.*, *Monograph. Nostoch.*, 1842, p. 89, tab. xii., fig. 13; West and West, *Brit. Desm.*, 1904, p. 58, pl. iv., figs. 23–32.

Sample 8, fairly common; previously recorded from South Georgia (Reinsch).

Two elongated pyrenoids mostly very obvious; length of cells = 50–54 μ; breadth = 13 μ.

32. Cylindrocystis crassa, *De Bary*, *Conj.*, 1858, pp. 37, 74, tab. vii., fig. c, 1–2; West and West, *Brit. Desm.*, 1904, p. 59, pl. iv., figs. 33–38.

Samples 8 and 9, fairly common.

Cells 32–35 μ long; 14–15 μ broad. Two rounded pyrenoids. Cells occasionally very slightly curved, with broadly rounded ends.

ZYGNEMACEÆ.

33. Mougeotia, sp.

Sample 8; only one filament of four cells seen.

Cells 31 μ broad; six times as long.

34. Zygnema, sp.

Sample 4 (red snow!); one very much shrunken filament of about twenty cells.

Diam. cell. = 28 μ; cells of the same length or one and a half times as long as broad.

C. HETEROKONTÆ.

CONFERVACEÆ.

35. Conferva bombycina, *Ag.*, *Syst.*, p. 83, n. 10; *Rabenh.*, *Fl. Europ. Alg.*, iii., 1868, p. 323.

Forma *minor*, *Wille*, *Algol. Mitteil.*, *Pringsh. Jahrb.*, xviii., p. 467.

Samples 8, 9, 10, and 15, rather rare.

Diam. cell = 6 μ; two to three times as long.

D. CYANOPHYCEÆ (Myxophyceæ).

CHROOCOCCACEÆ.

36. Synechococcus æruginosus, *Naeg.*, *Gatt. einzell. Alg.*, 1849, p. 56, tab. 1, e., fig. 1.

Sample 10, rather rare.

Cells isolated or in twos; diam. cell = 3 μ.

37. Entophysalis granulosa, *Kütz.*, *Phyc. gen.*, 1843, p. 177, pl. xviii., fig. 5.
Sample 16, common.

38. ? Aphanothece saxicola, *Naeg.*, *Gatt. einzell. Alg.*, 1849, p. 60, tab. 1, h, fig. 2.
Sample 11, rare.

39. Microcystis olivacea, *Kütz.*, *Phyc. gen.*, p. 170; *Rabenh.*, *Fl. Europ. Alg.*, ii., 1865, p. 51.

Samples 8, 9, 10, 11, and 14, rather common; previously recorded from Kerguelen (Reinsch).

40. Microcystis merismopedioides, n. sp. (text fig. 1, E, p. 122).

Familiæ parvæ solidæ circumferentia irregulari constant ex cellulis pusillis quæ muco fusco-flavescente vel rarius achroo et, ut videtur, tenaci cohærent. Cellulæ in facie familiæ quaternariæ regularissime dispositæ (ut in genere *Merismopedia*); dispositio cellularum in partibus interioribus familiæ investigari non potest, sed dispositio regularis verisimile est. Diam. fam. = 13–20 μ; diam. cell. fere 0·7 μ.

Samples 11 and 14, common.

In view of the very minute size of the cells and their dense aggregation, it has been impossible to determine exactly their arrangement in the interior of the solid colonies, but focussing in different planes seems to show that the same regular arrangement obtains all through. It is possible that this species belongs to the genus *Eucapsis*, described by Clements and Shantz (*Minnesota Bot. Studies*, iv., 1909, p. 134), but in the latter genus the colonies are described as cubical, which in no way applies to the rather irregular colonies of *M. merismopedioides*. They closely resemble those of a *Microcystis* in all except the regular arrangement of the minute cells.

41. Clathrocystis reticulata (*Lemm.*), *Forti*, *Sylloge Myxophycearum*, 1907, p. 96.

Sample 10, rather rare.

42. Gomphosphæria aponina, *Kütz.*, *Tab. Phyc.*, i., tab. xxxi., fig. 3; *Rabenh.*, *Fl. Europ. Alg.*, ii., 1865, p. 56.

Sample 11, rare.

43. Cœlosphærium kützingianum, *Naeg.*, *Gatt. einzell. Alg.*, 1849, p. 54, tab. 1, c.
Sample 11, rare.

44. Merismopedia glaucum (*Ehrb.*), *Naeg.*, *Gatt. einzell. Alg.*, 1849, p. 55, tab. 1, d, fig. 1.

Sample 11, rather rare.

45. Merismopedia tenuissimum, *Lemm.*, *Beitr. z. Kenntn. d. Planktonalgen*, *Bot. Centralbl.*, 1898, p. 154.

Sample 10, rare.

OSCILLATORIACEÆ.

46. OSCILLATORIA BREVIS, *Kütz.*; *Gomont, Oscillariées, Ann. Sci. Nat., Bot.*, xvi., p. 249, pl. vii., figs. 14–15.

Sample 10, rather rare.

47. OSCILLATORIA SPLENDIDA, *Grev.*; *Gomont, Oscillariées, Ann. Sci. Nat., Bot.*, xvi., p. 244, pl. vii., figs. 7–8.

Sample 10, rather rare.

48. OSCILLATORIA SUBTILISSIMA, *Kütz., Tab. Phyc.*, i., 1845–49, p. 27, tab. xxxviii., fig. 7.

Sample 10, rather rare.

49. OSCILLATORIA TENUIS, *Ag.*; *Gomont, Oscillariées, Ann. Sci. Nat., Bot.*, xvi., p. 240, pl. vii., figs. 2, 3.

Samples 10, 11, and 15, rather rare.

Forma *sordida*, Kütz., was also present.

50. SPIRULINA SUBTILISSIMA, *Kütz., Phyc. gen.*, 1843, p. 183; *Rabenh., Fl. Europ. Alg.*, ii., 1865, p. 93; *Gomont, Oscillariées*, p. 272, pl. vii., fig. 30.

Sample 10, rather common.

NOSTOCACEÆ.

51. ISOCYSTIS INFUSIONUM (*Kütz.*), *Borzi, Nuov. giorn. bot. ital.*, x., 1878, p. 468.

Samples 8, 11, 13, 15, and 17, rather common.

52. NOSTOC MINUTISSIMUM, *Kütz., Phyc. gen.*, p. 204; *Rabenh., Fl. Europ. Alg.*, ii., 1865, p. 162.

Samples 10 and 11, rather common; 1 and 3 (yellow snow!), rare.

RIVULARIACEÆ.

53. CALOTHRIX ÆRUGINEA, *Thuret*; *Bornet et Flahault, Nostocacées hétérocystées*, 1886–88, p. 358.

Sample 14, isolated.

Diam. cell = 9–11 μ. Only one group of filaments was seen, and the determination is therefore somewhat doubtful. *C. æruginea* is a marine form, but the habitat from which sample 14 came would be likely to harbour marine forms.

E. DIATOMACEÆ (Bacillarieæ).

54. MELOSIRA VARIANS, *Ag., Consp.*, 1830, p. 64; *Rabenh., Fl. Europ. Alg.*, i. 1864, p. 40.

Sample 9, rather rare.

55. Melosira sol, *Kütz.*; *Van Heurck, Atlas*, pl. xci., figs. 7–9.

Sample 4 (red snow!); one short chain seen (living); previously recorded from the Antarctic (Hooker and Harvey).

56. Coscinodiscus radiatus, *Ehrb.* (1838); *Rabenh., Fl. Europ. Alg.*, i., 1864, p. 34.

Samples 4 and 6 (red snow!), isolated; previously recorded from Kerguelen (Hooker and Harvey). A small form (diam. valve = 40–60 μ), otherwise agreeing with the existing descriptions.

57. Triceratium, sp.

Sample 4 (red snow!); only a single dead individual seen, but fragments of the valves common.

The single individual seen closely resembled Van Heurck's (*Atlas*, pl. cxii., fig. 1) and Wolle's (*Diatomaceæ of North America*, pl. cv., fig. 8) figures of *T. arcticum*, Bright, in the character of the areolæ (small at the three corners!); the general shape was more that of *T. repletum*, Grev., var. *balearica*, Grun. (Van Heurck, *Atlas*, pl. cx., fig. 7).

58. Synredra, sp.

Sample 11, rare.

59. Eunotia gracilis, *W. Smith, Brit. Diat.*, i., 1853, p. 16, and pl. xxx., fig. 249.

Sample 9, rather common.

A form with but very slightly recurved ends; length of valve = 22 μ; breadth = 2 μ.

60. Cocconeis costata, *Greg., Trans. Micr. Journ.*, v., p. 68, pl. i., fig. 27.

Samples 9 and 10, rare.

61. Navicula borealis (*Ehrb.*), *Kütz.*; *Van Heurck, Synopsis Diat.*, 1885, p. 76, pl. vi., fig. 3.

Samples 4 (rare), 9, 13, and 17, rather common; previously recorded from Cockburn Island (Hooker and Harvey).

Length of valve 35–58 μ; breadth 8–11 μ.

62. Navicula Braunii, *Grun.*; *Van Heurck, Synopsis Diat.*, 1885, p. 79, pl. vi., fig. 21.

Sample 10, very rare.

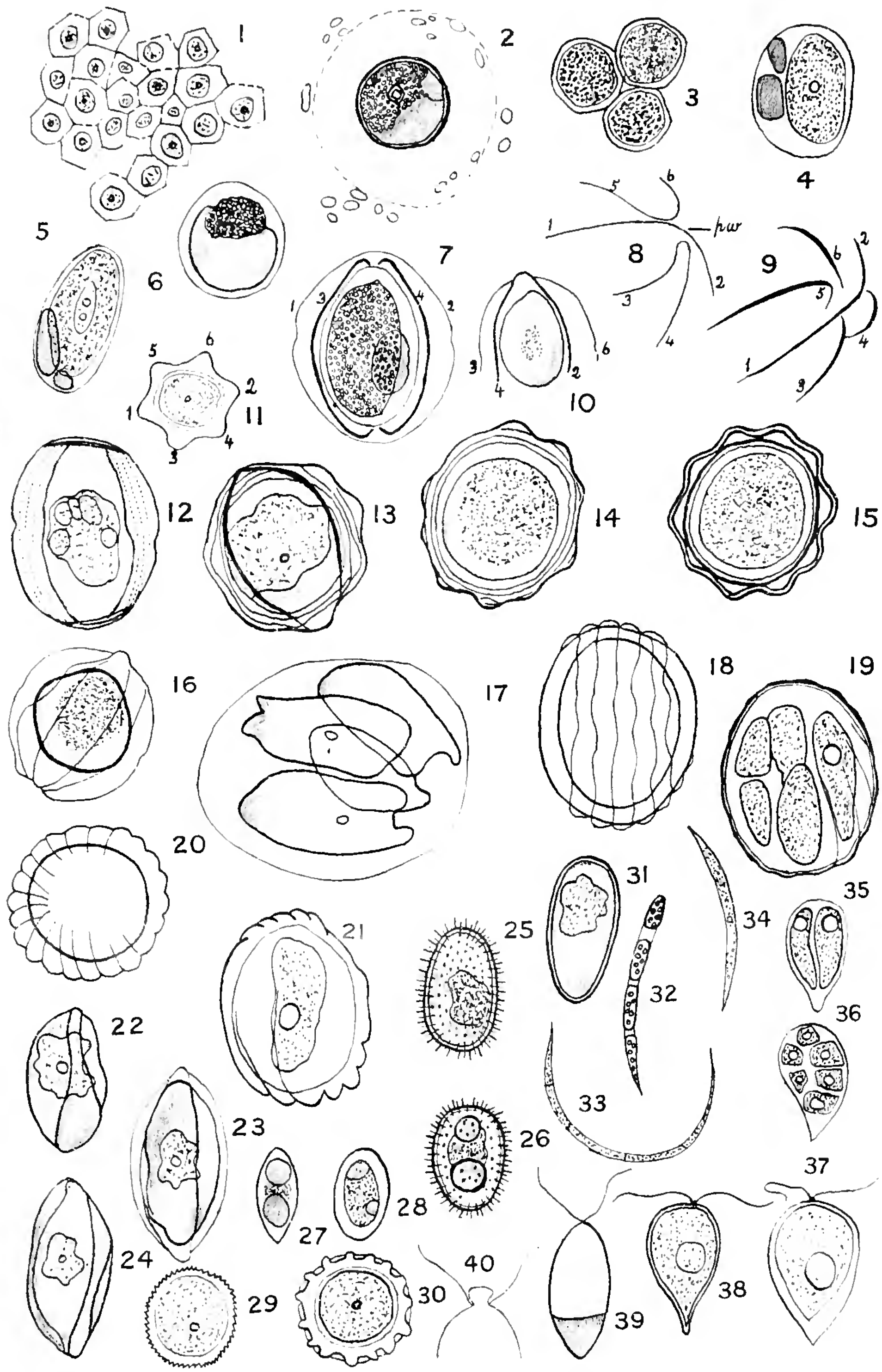
Length of valve = 37 μ; breadth = 12 μ.

63. Navicula Brébissonii, *Kütz.*, var. diminuta, *Van Heurck, Synopsis Diat.*, 1885, p. 77, pl. v., fig. 8.

Samples 9, 10, 13, and 15, rather common.

Length of valve = 20–34 μ (rarely 45–47 μ); breadth = 5–7 μ.

FRESHWATER ALGAE—FRITSCH I.



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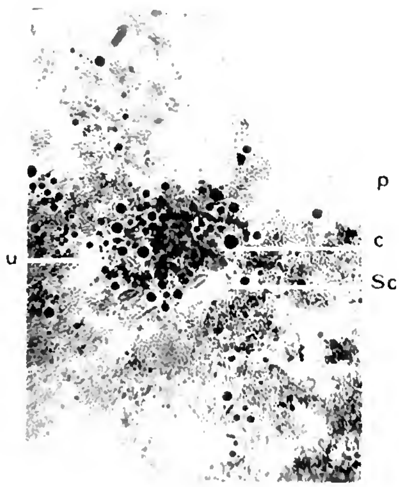
FRESHWATER ALGAE—FRITSCH II.



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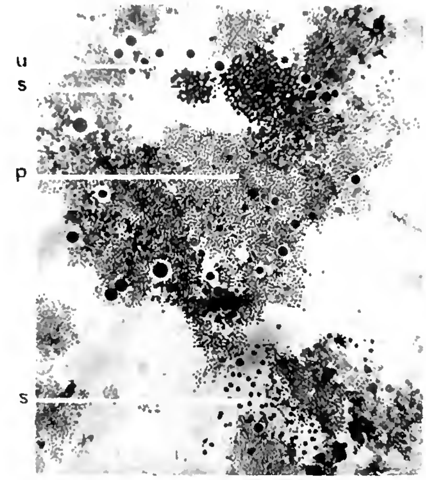

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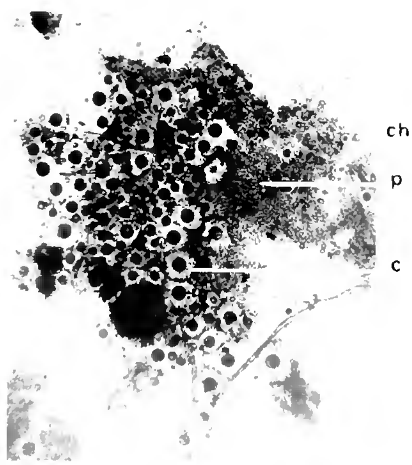

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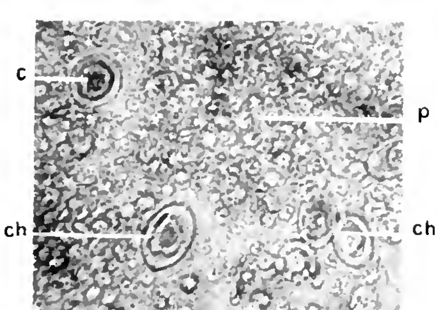

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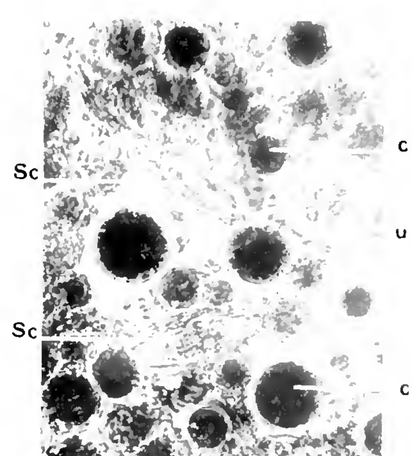

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64. Navicula muticopsis, *Van Heurck, Diatomées, Résult. voyage du s.y. "Belgica,"* Anvers, 1909, p. 12, tab. 2, fig. 181 (text fig. 1, B, p. 122).

Samples 8, 9, 10, 11, and 15, common; previously recorded from the Antarctic (Van Heurck, Messrs West).

Length of valve = 21–24 μ; breadth (at widest point) = 10 μ.

In most of the individuals the sides were quite flat, but in others they were somewhat arched; ends pronouncedly swollen in a capitate manner. Such capitate forms approach *N. dicephala* (Ehrb.), W. Smith.

65. ? Navicula lucidula, *Grun.*; *Van Heurck, Atlas*, 1880–81, pl. xiv., fig. 40.

Sample 9, rather rare.

Certainly a very close ally of this species.

66. Navicula mutica, *Kütz.*; *Van Heurck, Synopsis Diat.*, 1885, p. 95, pl. x., fig. 17.

Samples 8, 9, 10, 13, and 17, common; previously recorded from the Antarctic (Reinsch, Holmboe).

Length of valve = 16–35 μ; breadth = 7–11 μ (incl. f. *Göppertiana*, Bleisch).

67. Amphora ovalis, *Kütz.*; *Van Heurck, Synopsis Diat.*, 1885, p. 59, pl. i., fig. 1.

Sample 4 (red snow!), isolated; the var. *gracilis* has previously been recorded from Kerguelen (Reinsch).

68. Gomphonema montanum, *Schum.*; *Van Heurck, Synopsis Diat.*, 1885, p. 124, pl. xxiii., figs. 33 and 36.

Sample 9, isolated specimens.

EXPLANATION OF THE PLATES.

Plate I.

Fig. 1. *Protoderma brownii*, n. sp.—A small portion of one of the sheets of cells formed by this species (× 830).

Figs. 2–6. *Chlorosphæra antarctica*, n. sp.—Fig. 2. Large isolated cell with a wide mucilage-sheath and a quantity of fat in the cell-contents (× 540). Fig. 3. A group of small cells without mucilage-sheath; fat equally diffused through the contents (× 1100). Figs. 4–5. Oval cells with segregated masses of fat; possibly a stage in which the cells are preparing to divide (*cf.* p. 104) (× 830, 730 respectively). Fig. 6. A cell in which the fat is very prominently developed (× 540).

Figs. 7–11. *Scotiella antarctica*, n. sp.—1–2 = principal wings; 3–4 and 5–6 = the two pairs of lateral wings; *pw* = principal wings. Fig. 7. A rather small normal individual, as seen when the principal wings are parallel to the substratum (× 830). Figs. 8, 9. Two oblique end-views of the organism to show the course of the wings (× 830). Fig. 10. Part of a normal individual in which the principal wings are inclined to the substratum (× 540). Fig. 11. An individual seen in optical section (× 430).

Figs. 12–16. *Scotiella antarctica*, n. sp. — Stages in formation of resting-spores (?). Fig. 12. An individual in which the wings have lost in definition (× 540). Figs. 13, 14, 15. Three stages in the production of the resting-cell (× 540). Fig. 16. An early stage in the formation of a resting-cell; contents rounded off and wings irregular (× 410).

Fig. 17. *Scotiella antarctica*, n. sp.—A possible stage in the production of four new individuals (× 1100).

Figs. 18–21. *Scotiella polyptera*, n. sp.—Fig. 18. An individual seen from the side, showing the numerous undulated wings; contents not figured (× 1100). Fig. 19. Production of four new individuals; wings on mother-cell indistinct, but showing the spiral trend (× 1500). Fig. 20. Oblique end-view of an individual to show the course of the wings (× 1100). Fig. 21. A normal individual seen from the side, showing the shrunken cell-contents, the spiral wings, and the crenate outline of the whole cell (× 1100).

Figs. 22–24. *Pteromonas nivalis* (Shuttelw.), Chod. — Three individuals showing the course of the wings and the contracted contents (× 830).

Figs. 25, 26. *Chodatella brevispina*, n. sp.—Two individuals showing different methods of distribution of the fat (× 830).

Figs. 27, 28. *Oocystis lacustris*, Chod., f. *nivalis*.—Two isolated cells from the yellow snow (× 830).

Fig. 29. *Trochiscia nivalis*, Lagerh. (× 1100).

Fig. 30. ,, *antarctica*, n. sp.—From the yellow snow (× 1100).

Fig. 31. *Pteromonas nivalis* (Shuttelw.), Chod.? (× 1100).

Figs. 32, 33. *Raphidonema nivale*, Lagerh. (× 830).

Fig. 34. *Raphidium pyrenogerum*, Chod.? (× 1100).

Figs. 35–40. *Chlamydomonas caudata*, Wille.—Figs. 35, 36. Subdivision of the cell-contents (× 650). Figs. 37, 38. Two normal individuals (× 750). Fig. 39. Individual with a very strongly thickened posterior tip (× 750). Fig. 40. Front-end of an individual to show a prominent beak between the two cilia (× 830).

Plate II.

All the photographs[1] on this plate are representations of stained material of yellow snow at various magnifications. The following symbols are used:—*C* = *Chlorosphæra antarctica*, F. E. Fritsch; *Ch* = *Chodatella brevispina*, F. E. Fritsch; *P* = *Protoderma brownii*, F. E. Fritsch; *S* = *Sphærocystis schroeteri*, Chod., f. *nivalis*; *Sc* = *Scotiella antarctica*, F. E. Fritsch; *U* = *Ulothrix*. (Photographs 1, 2, and 3 are magnified 130 times; photographs 4, 5, and 6 are magnified 400 times.)

Photographs 1 and 2.—Typical views of the yellow snow flora at a low magnification. In the first photograph *Protoderma brownii* is very predominant, but in the centre is seen a group of fairly large *Chlorosphæra*-cells, together with three individuals of *Scotiella antarctica*. Short filaments of *Ulothrix* are visible at several points on the photograph. The second photograph shows a very typical stratum of *Protoderma* near the centre, two young colonies of *Sphærocystis* at the upper end, and an older colony towards the base. *Chlorosphæra*-cells of various sizes and often exhibiting well-marked mucilage-sheaths are obvious at many points in the photograph.

Photograph 3.—This shows a very typical group of large *Chlorosphæra*-cells, with well-marked sheaths, together with a thick patch of *Protoderma*. At the right-hand side of the photograph a number of individuals of *Chodatella* are to be seen.

Photograph 4.—An individual of *Scotiella antarctica*, F. E. Fritsch, showing the two principal and two lateral wings. The notch in the right-hand principal wing is very obvious. At the lower end of the individual the two lateral wings can be seen curving inwards.

Photograph 5.—A small part of a *Protoderma*-sheet highly magnified (only the cell-contents are recognisable); this photograph also shows a number of individuals of *Chodatella brevispina*, F. E. Fritsch. The small spines on the latter are scarcely visible.

Photograph 6.—This shows part of the central group of cells in photograph 1 on an enlarged scale. Three individuals of *Scotiella*, a number of *Chlorosphæra*-cells, and *Ulothrix*-filaments are visible, while the ground-mass consists of *Protoderma*.

[1] The photographs on this plate were made with the help of a photomicrographic apparatus purchased by a research-grant made by the Governors of the East London College, University of London. I am much indebted to my friend Mr E. Hatschek for assistance in taking these photographs.

X.—NOTES ON ANTARCTIC BACTERIOLOGY.

X.—NOTES ON ANTARCTIC BACTERIOLOGY.

By J. H. Harvey Pirie, B.Sc., M.D., F.R.C.P.Ed., Surgeon and Geologist to the Scottish National Antarctic Expedition.

Extensive bacteriological investigations did not come into the programme of work undertaken on the *Scotia*, but, considering the paucity of bacteriological observations in the Antarctic regions, it seems desirable to publish those made, the more so, since, comparatively few as they are, they are in some respects different from those made by some of the other recent Antarctic expeditions; in others, complementary.

The outfit at my disposal consisted of a supply of nutrient agar and gelatine tubes—many of the latter of which, unfortunately, were ruined in the passage through the tropics,—a small steam steriliser, a small incubator, and minor accessories. Materials were also taken for the manufacture of media, but, although it was found quite practicable to make up those media, for instance, employed for the cultivation of denitrifying organisms, and simple gelatine media, it was found almost impossible to make agar media on board, owing to the constant contamination with moulds. This difficulty with moulds has been the experience of all who have attempted bacteriological work at sea: every time a tube or flask is opened mould is liable to get in, and many of one's cultures and stock media are ruined. Not only this, but the majority of the films which I made, as the work was being carried on, to bring home for staining, were spoilt by mould. I would advise anyone, therefore, attempting such work on a future occasion to have, as far as possible, all media prepared before the departure of the expedition, and to stain all films which it is desired to keep. No attempt was made to bring home live cultures of organisms, although a number were brought back, preserved with formalin vapour and sealed. Under these conditions, of course, exact determinations of bacterial species are impossible. Difficulties with the incubator and the necessity of economy in oil fuel led to the use, for the most part, of a warm corner of the engine-room as an incubator. The irregular variations in the temperature were not conducive to the best results in obtaining cultures, but, nevertheless, a number did grow satisfactorily. During the eight months that the ship was frozen up at the South Orkneys, bacteriological work, beyond some air observations, came to a standstill; whilst during my stay in those islands, when the *Scotia* went north, the most that could be done was to make cultures which awaited the vessel's return for incubation.

A number of these were, however, successful. The observations may be divided into those on—

1. The alimentary canal of Antarctic animals.
2. Sea water.
3. Air.

1. Bacteriology of Alimentary Tracts of Antarctic Animals.

Whether or not bacteria play an essential rôle in vertebrate economy by their action in the alimentary tract, particularly the intestines, is a point which need not be discussed here, but the observations of Levin in Spitsbergen appear to show that in Arctic birds and seals the intestines may harbour no bacterial flora. It was a point, therefore, of considerable interest to see if similar conditions prevailed in the Antarctic regions where, considering how much more these are cut off from the rest of the world, one might, on general grounds, expect them to be even more probable. My observations, however, so far as they go, point rather in the other direction, namely, that bacteria are present as a rule in the intestines of the seals and birds, although I certainly was not successful in obtaining them in all the species examined. The following table shows the species from which I made cultures; the result, whether positive or negative; and some brief notes on the character of the growths and organisms obtained.

Nos. 1 and 2 were inoculated from a Cape pigeon which had been 24 hours killed. Growth appeared in No. 2, an agar stab culture, in 24 hours, both on the surface and down the needle track. A moist white growth, most active on the surface, taking on a yellow tinge as it grew thicker. Sub-culture on gelatine as a streak culture gave a slimy thick white growth, developing into two thick ridges on either side of the streak. Apparently pure culture of a stout short bacillus, with rounded ends, actively motile, Gram $-$ve, terminal spores (?) or polar staining.

No. 4.—Agar stab culture from intestine of ringed penguin. Growth in 24 hours, chiefly on the surface. Colonies moist, white, granular, becoming brownish in centre.

No. 6.—Agar stab culture from large intestine of Ross seal. Growth in 24 hours. Thin moist slimy growth on surface, with crenated edge. Extensive growth from stab, in form of branches into medium into fuzziness round each branch.

No. 7.—Gelatine stab from same as No. 6. Good growth in 3 days. White on the surface. Cup-shaped depression formed but no liquefaction.

No. 14.—Gelatine stab from intestine of Emperor penguin 20 hours killed. Liquefaction of medium, but this may have been due to a mould which was found to have got in.

No. 15.—Agar stab culture from same as No. 14. White irregular growth on surface, but not extending for any distance down the stab. Strong fæcal odour in the tube. A mixed growth.

No. 18.—Agar stab culture from intestine of cormorant. Growth visible only after 4 days. A moist white surface growth. None along stab.

TABLE I.

No.	Source.	Medium.	Growth + ve or – ve.	Characters of Bacteria, etc.
1	Cape pigeon (intestine)	Agar	–	From bird 24 hours killed.
2	Do.	Agar	+	From same bird as No. 1. A short stout motile *bacillus*, with rounded ends. Gram negative. Polar staining.
3	Snowy petrel (intestine)	Agar	–	From bird 12 hours killed.
4	Ringed penguin (intestine)	Agar	+	From bird 3 hours killed. Short *bacillus*, actively motile, rounded ends, some longer filamentous involution forms. Gram negative.
5	Do.	Gelatine	–	From same bird as No. 4.
6	Ross seal (intestine)	Agar	+	Mixed growth. Chiefly Gram – ve *bacilli*, short stout round ends, many showing polar staining. Some much longer forms. Also some large Gram + ve *cocci* in short chains.
7	Do.	Gelatine	+	*Bacillus* similar to that in No. 6, but rather larger and thinner rods. Usually occur in pairs end-to-end.
8	Crab-eating seal (stomach)	Gelatine	–	From seal 24 hours killed.
9	Emperor penguin (stomach)	Gelatine	–	From penguin just killed. "Incubator" temperature very unsteady, which may account for negative results.
10	Do.	Agar	–	
11	Emperor penguin (intestine)	Agar	–	
12	Snowy petrel (intestine)	Agar	–	From petrel 14 hours killed. Incubated at temperature of only 70° F.
13	Snowy petrel (stomach)	Agar	–	
14	Emperor penguin (intestine)	Gelatine	+	From penguin 20 hours killed. Short and long *bacilli*. Some, if not all, motile. Growth early spoilt by mould.
15	Do.	Agar	+	Mixed growth. Large Gram – ve *coccus* or *cocco-bacillus* and small delicate motile *bacilli*. Strong fæcal odour from culture.
16	Fish—*Notothenia coriiceps* (intestine)	Agar	–	From fish just caught. Incubated in laboratory at temperature varying between 35° F. and 55° F.
17	Do.	Medium G for denitrifying organisms	–	
18	Cormorant—*Phalacrocorax atriceps* (intestine)	Agar	+	A *coccus*, in couples or in clumps. Apparently motile. Very similar to *Staphlyococcus pyogenes albus* in films, but is Gram – ve.
19	Gentoo penguin (intestine)	Agar	–	From a chick about 3 days old.
20	Crab-eating seal (intestine)	Agar	–	
21	Wilson petrel (intestine)	Agar	–	
22	Weddell seal (intestine)	Agar	–	
23	Sea-leopard (intestine)	Agar	–	

TABLE I.—*continued.*

No.	Source.	Medium.	Growth + ve or – ve.	Characters of Bacteria, etc.
24	Giant petrel (intestine)	Agar	+	Mixed growth. Gram + ve *cocci*, Gram + ve *diphtheroid bacilli*, and small Gram – ve *bacilli*.
25	Weddell seal (intestine)	Agar	+	Growth early spoilt by mould.
26	Ringed penguin (intestine)	Agar	+	Large Gram + ve *cocci*.
27	Adelia penguin (intestine)	Agar	–	
28	Gentoo penguin (intestine)	Agar	–	
29	Snowy petrel (intestine)	Agar	+	From a nestling. Abundant Gram + ve *cocci*, like *Staphylococci* in films. Also a large Gram – ve *coccus* or *cocco-bacillus*.
30	Antarctic skua (intestine)	Agar	+	From a nestling. Large Gram – ve *coccus* or *cocco-bacillus*, short, stout, round-ended. Gram – ve *bacillus* with numerous very long spindle-shaped involution forms.
31	Sheathbill (intestine)	Agar	–	From a nestling.
32	Sea-leopard	Agar	+	Some Gram + ve *cocci*, single or in clumps. A few very stout round-ended Gram + ve *bacilli*, mostly in pairs, end-to-end. Abundant Gram – ve *bacilli*, short stout forms with rounded ends, and fairly numerous longer thread-like forms.
33	Crested penguin —*Catarrhactes chrysolophus* (intestine)	Agar	–	
34	Gentoo penguin (intestine)	Agar	+	Small Gram – ve *cocco-bacillus*. A few very large Gram – ve *streptobacilli*.
35	Blue petrel (intestine)	Agar	+	Culture lost.
36	Tern—Sp. incert. (intestine)	Agar	+	Culture dried. No organisms could be found on trying to make films.
37	Sooty albatross (intestine)	Agar	+	A large Gram – ve *coccus*, mostly in pairs, sometimes clumps, also in short chains.

No. 24.—Agar stab culture from intestine of giant petrel. Growth visible only after 5 days, and only as a surface growth. After 3 weeks the appearance of the growth was that of a dry crinkled growth, very similar to that of an old culture of tubercle bacilli on potato. This is a mixed growth, however.

No. 26.—Agar stab culture from intestine of ringed penguin. Growth visible after 3 days as a dry white surface growth.

No. 30.—Agar stab culture from intestine of an Antarctic skua, chick. A mixed surface growth, one a dry crinkled brownish raised growth, overgrown by a moist, somewhat yellowish film.

No. 37.—Agar stab culture from intestine of sooty albatross. Growth visible in 4 days as a dry brownish raised crinkled surface growth.

The following table shows the same data grouped according to the species of animal from which inoculations were made, with +ve or −ve results :—

TABLE II.

Species.	No. of Cultures Inoculated.	Growth.	No Growth.
Cape pigeon	2	1	1
Snowy petrel	4	1	3
Wilson petrel	1	0	1
Giant petrel	1	1	0
Blue petrel	1	1	0
Sooty albatross	1	1	0
Ringed penguin	3	2	1
Emperor penguin	5	2	3
Gentoo penguin	3	1	2
Adelia penguin	1	0	1
Crested penguin	1	0	1
Cormorant	1	1	0
Antarctic skua	1	1	0
Sheathbill	1	0	1
Tern	1	0	1
Weddell seal	2	1	1
Ross seal	2	2	1
Crab-eating seal	2	0	2
Sea-leopard	2	1	1
Fish	2	0	2
20 species.	37	16	21

Growths of one or more species of bacteria were therefore obtained from the alimentary tract of 13 of the 20 species examined; from 3 of the 4 species of seals, and from 10 of the 15 species of birds. Although this seems a very poor result, it is really large when compared with the numbers of positive findings obtained on other expeditions. Dr Ekelöf obtained a bacillus twice from the intestinal contents of Antarctic skuas, but failed to get any growth from the same species on other occasions, and also could get no growth from Adelia penguins, gentoo penguins, terns (*Sterna hirundinacea*), or cormorants (*Phalacrocorax atriceps*). Dr Gazert, from Weddell seals, crab-eating seals, and sea-leopards, always obtained bacteria in the large intestine; more rarely in the small intestine and stomach. In the stomach and intestinal contents of the following birds he found no bacteria, either by aerobic or anaerobic cultivation :—King penguins, Adelia penguins, Antarctic petrels, snowy petrels, terns (*Sterna hirundinacea*), and a species of *Priofinus*. Only from one tern and one Adelia penguin were growths obtained, and in neither case could fallacy from accidental contamination be excluded. Dr Charcot reports that the examination of fæcal matter from the intestines of various seals, birds, and fishes showed the presence of numerous and various bacteria, in smaller numbers, however, than in temperate regions. He brought home a number of live cultures from seals, gulls, penguins, petrels, and fishes, from which Mlle. Tsiklinsky was able to isolate in pure culture

24 species of bacteria, of which 15 could be identified with well-known forms, the others being apparently new species or varieties. Those from the fish, in particular, appeared to be very polymorphic and indefinite in their characteristics.

The net result, therefore, so far, seems to be that the alimentary tracts of Antarctic vertebrates contain in all cases relatively few bacteria, and that in a number of instances they appear to be altogether sterile, or, at all events, any bacteria they may contain fail to grow on the ordinary commonly used nutrient media.

2. Bacteriology of Sea Water.

These observations included—

(*a*) Those made on ordinary culture media—chiefly gelatine.
(*b*) Examinations for the presence of denitrifying bacteria.
(*c*) Quantitative examinations.
(*d*) Examination of deep-sea samples and bottom muds.
(*e*) Examination for the presence of nitrifying bacteria.

(a) *Observations on Bacteriology of Surface Water of Scotia Bay, South Orkneys, taken during the summer months, Dec. 1903, Jan. and Feb. 1904.*

Table III.

No.	Medium.	Growth + ve or – ve.	Nature of Organisms, etc.
1	Fish peptone bouillon	+	Evident turbidity and growth after 5 days A small actively motile *bacillus* with rounded ends. Often in short chains. Also some long *spirillum*-like organisms, less actively motile.
2	Gelatine	–	
3	Gelatine	–	Mould colony.
4	Gelatine	+	Numerous small white colonies after a week. Some liquefaction after a month. Principal organism is a fairly large spherical body, but with considerable variation in size; looks like a *Torula*. Appearance of a "nucleus" both in hanging-drop preparations and stained films. Indefinite as regards its staining by Gram's method. Also *sickle-shaped bodies*, a few *diplococci*, and a very few small motile *bacilli*.
5	Gelatine	–	
6	Fish peptone bouillon	+	Tube broken.
7	Gelatine	+	A few small white surface colonies. An organism very like a *Sarcina* or *Micrococcus tetragenus* in films, but Gram – ve
8	Gelatine	+	Numerous white opaque surface colonies. Both macroscopically and microscopically look like *Staphylococcus pyogenes albus*, only they are Gram – ve, and do not liquefy gelatine.
9	Gelatine	+	White colonies of a *Torula*-like organism apparently identical with that in No. 4.
10	Gelatine	+	No note of nature of organism.

These cultures were made with a few drops of the surface water taken some distance from the shore, the temperature of the water at this season varying between 29° F. and 33° F. Incubation was carried out by keeping the tubes in Omond House, where the temperature varied between 45° F. and 60° F. The gelatine was in the form of sloped tubes.

Seven of the ten cultures yielded growths, three did not. It is probable that the number of bacteria in Antarctic sea water capable of growing on ordinary nutrient media is comparatively small. It may be mentioned that Dr Ekelöf from his quantitative observations found on an average 4·4 organisms per c.c., and never more than 21. Dr Gazert, on the German Expedition, from 0 to 10 per c.c. A few cultures brought home by Dr Charcot yielded two coccal forms, three species of bacilli, and two yeast or *Torula* forms. From their description I am inclined to regard the organisms I observed as very similar forms. Dr Ekelöf isolated five different species, all spirillar or bacillary forms. I have not yet seen Dr Gazert's full report, so am unable to say what was the character of the organisms he obtained.

(b) *A Number of Examinations of Surface Sea Water made to ascertain whether Denitrifying Organisms were present or not. The following media were used for this purpose.*

A.		B.		C.		G.
Sea water	100 c.c.	Sea water	100 c.c.	Sea water	100 c.c.	100 c.c. of C + 10 grm. gelatine Melted, sterilised, and solidified.
Calc. malate	0·5 grm.	Calc. malate	1 grm.	Glucose	1 grm.	
K_2HPO_4	0·1 ,,	K_2HPO_4	0·05 ,,	K_2HPO_4	0·05 ,,	
				KNO_3	0·1 ,,	
KNO_3	0·1 ,,	KNO_3	0·1 ,,	Chalk	a pinch	

H.	
Equal parts of C and agar. Melted, sterilised, and solidified.	A, B, and C are media which were used by Professor Gran in some of his North Sea bacteriological work. These media were sterilised in bulk by boiling in flasks, and control experiments were made occasionally with uninoculated media. They were found to be quite free from bacteria, although on several occasions moulds got access to them. For use from 5 to 7 c.c. were poured into a sterilised test-tube and inoculated with two drops of the water to be examined.

The observations were all made on surface waters from various localities in the Weddell Sea during the first summer's cruise in 1903. The surface water temperatures at this time were all between 29° F. and 30° F. The inoculated tubes were, as a rule, kept at first in the laboratory, where the temperature varied between about 35° F. and 55° F.; but as it was found that very little growth or denitrification occurred, they were later transferred to a temperature kept more or less steadily about 60° F.

The following brief notes taken from my notebook regarding a few of these may be taken as fairly typical of the whole :—

No. 2. Medium B.—Contains a small motile *bacillus* occurring sometimes in short chains.

No. 6. Medium C.—Contains short motile *bacilli*, mostly in pairs, others curved, longer, and non-motile, a few very long *vibrio*-like forms, non-motile.

After a week kept in a temperature not much above 32° F. no growth visible. Transferred to laboratory—10 days later abundant nitrite ; a week later strong ammonia reaction ; nitrite still present.

No. 10. Medium H.—Small actively motile *bacilli* ; a few larger forms. Kept in laboratory. After 12 days trace of nitrite, strong ammonia. After 20 days nitrite all gone, still strong ammonia.

Nos. 11 and 12. Medium A and medium B (16th Feb. 1903, from 62° 52′ S., 25° 00′ W.).—Incubated in laboratory. Trace of nitrite after 8 days. Transferred to 60° F. Strong nitrite and slight ammonia reaction 6 days later. Presence of an organism resembling *Euglena*, similar to that in No. 14.

No. 14. Medium A (17th Feb. 1903, from 64° 18′ S., 23° 09′ W.).—Incubated in laboratory. After 15 days no nitrite reaction. Transferred to 60° F. In 7 days a strong nitrite reaction, later also ammonia. No *bacilli* seen, but numerous rounded motile bodies with a flagellum, resembling *Euglena*. Query—Are they nitrate reducers ? Later a few *bacilli* were seen.

No. 17. Medium G.—No growth visible after 8 days in laboratory. After 11 days, at 60° F., five small white colonies appeared, which very slowly grew larger. All consisted of a *coccus*, chiefly in *diplococcus* form.

No. 19. Medium C.—Grown anaerobically by Buchner's method. When opened after 3 weeks tube contained a few motile *bacilli*, others non-motile or dead. No nitrite ; no ammonia. Etc., etc.

Growth in the liquid media was usually indicated by its becoming turbid, but this was always controlled by microscopic examination of hanging-drop preparation. Every-one made gave + ve growths, including one anaerobically. All save three gave a definite reaction of nitrite formation when tested with KI, starch, and H_2SO_4. Of these three, one was an anaerobic culture (the only one made), the other two made from water taken, not in the open sea but near the head of Scotia Bay, South Orkneys, when we settled down there for winter quarters. The majority, but not all, gave later a reaction for ammonia when tested with Nessler's reagent. Medium C, upon the whole, appeared to be the most suitable medium for these organisms ; but the rate of growth and of production of nitrite and of ammonia seemed to vary considerably, but it was always very slow. In no case could I demonstrate any denitrification in tubes kept at a temperature varying somewhat indeed, but never very much above 32° F. At the temperature of the laboratory, varying usually between 35° F. and 55° F., growth and denitrification was, in most cases, proceeded with very slowly ; but when incubated at a temperature kept fairly constantly about 60° F., both proceeded more rapidly, although still slowly compared with results obtained in more temperate seas. From these observations, therefore, it may be stated that the presence of organisms with denitrifying properties seems to be fairly constant in the surface waters of the

Weddell Sea; but, judging by the results obtained in cultures kept at temperatures approximating to those constantly prevailing in that sea, and even in those kept at temperatures considerably higher, it seems at least doubtful if much active denitrification can be carried on by bacteria in those waters. The question of denitrification being carried on by organisms other than bacteria, such as *Euglena*, seems possible from three or four observations (see Nos. 11, 12, and 14 quoted above).

Brandt in particular has pointed out the important rôle played by denitrifying organisms in marine metabolism, setting free again the great mass of nitrogen which is brought into the ocean in the form of nitrate, nitrite, and ammonia salts, and breaking down dead organic matter. He has propounded the view, based on the fact that polar seas are very rich in plankton, while tropical seas are comparatively poor, that the activity of denitrifying organisms is far greater in warm seas than in cold, while nitrification, on the other hand, is probably more active in polar seas. In other words, in polar seas, owing to the low temperatures, the denitrifiers cannot break down nitrogen-containing matter to the same extent, so that a richer plant life, and, in consequence, a richer animal life, can exist in them than in warm seas where the nitrogenous matter is broken down, often to the extent of liberating free nitrogen.

These investigations certainly tend to support Brandt's views to a considerable extent. The presence of active nitrification could not be substantiated, as is mentioned further on, nor is it from the observations of Dr Gazert, who also failed to obtain any evidence of marine nitrifying organisms. The presence of denitrifying organisms, on the other hand, seems to be widespread in the Weddell Sea, but their activity under the low temperature conditions prevailing seems to be very slight.

Gazert records fairly similar conditions. Using Bauer's media, which I did not employ, he found denitrifying organisms to be present in the cold Antarctic waters, though apparently in very small numbers. With regard to their activity, he found that at temperatures from 5° C. to 10° C. (40° F. to 50° F.) denitrification proceeded very, very slowly, but fairly actively between 20° C. and 25° C. (68° F. to 77° F.). Using Gran's media, however, he does not appear to have obtained denitrifying organisms.

(c) *Quantitative Estimations of the Bacterial Content of Sea Water.*

1. Surface water, 13th Feb. 1903, lat. 59° 43′ S., long. 30° 44′ W. Medium G (see under notes on "Denitrifying Organisms"), 1 c.c. of water melted in with the medium in a Petri dish. Incubated in laboratory, temperature 35° F. to 55° F.

   Result, 170 colonies.
2. Same as No. 1, only incubated at 60° F.

   Result, 334 colonies.
3. Surface water, 24th Feb. 1903, lat. 69° 52′ S., long. 17° 22′ W. Medium G. 1 c.c. of water. Incubated first in laboratory; later at 60° F.

   Result, 35 colonies.

4. Same as No. 3, but medium consists simply of gelatine, 10 grm., sea water 100 c.c. Incubated in laboratory.

   Result, 112 colonies.

5. Water from 2000 fathoms, 6th March 1903, lat. 67° 39′ S., long. 36° 10′ W. Out of Buchanan-Richard water-bottle. Medium G. Inoculated Petri dish with 5·2 c.c. of the water. Incubated at 60° F.

   Result, 2 colonies.

   Could not absolutely exclude contamination from surface waters. The growths consisted of small motile *bacilli.*

6. Water from 2485 fathoms (15 fathoms above the bottom), 6th March 1903, lat. 67° 39′ S., long. 36° 10′ W. Out of Buchanan-Richard water-bottle. Medium G. 5·3 c.c. water inoculated. Incubated at 60° F.

   Result, 1 colony.

   Here, also, surface contamination could not be absolutely excluded. The growth was of a very minute motile *bacillus*, which produced slight liquefaction of the gelatine. Sub-culture in medium C was sterile.

Three of the four estimations of surface water, yielding respectively 170, 334, and 35 colonies per c.c. of water, were made on media suitable for denitrifying organisms, so are not comparable with the results obtained by Dr Gazert and Dr Ekelöf, who, on ordinary media, never obtained more than 21 colonies per c.c., and usually a much smaller number. One observation made on sea-water gelatine yielded 112 colonies from 1 c.c. of water. I can offer no explanation for this difference in results. It may be that the surface water of the open Weddell Sea is really more rich in bacteria than the waters nearer inshore, such as were examined by Dr Ekelöf Those examined by Dr Gazert, however, cover a much wider area of sea, much of it open ocean. It is not fair to judge, of course, from one isolated observation, but so far as I am aware there was no error in my technique, and I can only leave the figure to stand for future corroboration or disproof.

(d) *Examination of Deep-sea Samples for the Presence of Bacteria.*

Sixteen samples of bottom mud, bottom water from the Buchanan sounding tube, and of waters from various intermediate depths from 100 fathoms downwards, taken from Buchanan-Richard or Nansen-Petersen water-bottles, were examined, all from the Weddell Sea area. From 5 to 10 c.c. were inoculated in tubes or Petri plates, the media used being G (chiefly), C, A, and B (see under "Denitrifying Bacteria"). They were incubated either in the laboratory (temperature 35° F. to 55° F.) or at 60° F. The conditions under which the samples were obtained did not absolutely preclude surface water contaminations, but the results do not look as if this had occurred, for of the sixteen only three yielded any growth. Two of these, on medium G, are referred to in more detail above under "Quantitative Estimations," rather over 5 c.c. of water in each case yielding respectively 2 colonies and 1 colony. The third was an inoculation of water out of a Buchanan water-bottle from a depth of 2550 fathoms, *i.e.* bottom water (16th March 1903, lat. 63° 51′ S., long. 41° 50′ W.), on medium F (described under "Nitrifying Organisms"), the only sample tried in this medium. Inoculations of water from the same sample in media A and B proved sterile, but in F there grew very slowly a short motile *bacillus*, occurring singly, in couples, and also in short chains, the chain formation being more pronounced than in any other marine bacterial growth which I obtained. No ammonia or nitrate was formed in the medium.

Dr Gazert, in waters down to 800 metres deep, found germs absent or very few in number (from 1 to 3 in 10 c.c.). Bottom-water samples were either sterile or yielded from 3 to 6 bacteria in 10 c.c. Ooze water, *i.e.* the layer of water just touching the bottom, was not so often germ-free. The oozes and muds themselves appear to be always sterile. Nitrifying and denitrifying organisms were not found in any of his deep-sea samples.

(e) *Examination of Sea Water for Nitrifying Organisms.*

The media employed as suitable for the growth of nitrite- and nitrate-forming organisms were as follows :—

D.		F.	
Salt water	100 c.c.	Salt water	100 c.c.
$(NH_4)_2SO_4$	0·2 grm.	$NaNO_2$	0·1 grm.
K_2HPO_4	0·1 ,,	K_2HPO_4	0·05 ,,
$MgSO_4$	0·05 ,,	$MgSO_4$	0·03 ,,
$CaCO_3$	several grammes	Na_2CO_3	0·05 ,,

Five inoculations were made in each medium with surface water from various parts of the Weddell Sea area, during February 1903, but in no case save one did any growth occur after incubation at varying temperatures between 32° F. and 60° F. In one instance a slight growth occurred in an inoculated tube of medium F, but the organism was evidently a denitrifier and not a nitrifier, for ammonia was found but no nitrate.

One deep-water sample inoculated in medium F also gave a growth, but neither ammonia nor nitrate was found in this instance (see under "Deep-Sea Samples").

The conclusion to be drawn seems to be either that nitrifying organisms are not present in these waters, or that the media employed were not suitable for their growth.

Dr Gazert, using Winogradski's medium (without silicate), also failed to get any evidence of nitrification going on through the action of bacteria in Antarctic waters.

3. Air Examination for the Presence of Bacteria.

Several examinations were made by exposing plates of agar and of medium G (for denitrifying organisms) on the top of the deck laboratory during the voyage in the Weddell Sea in 1903. These cannot be considered satisfactory, owing to the possibility of contamination from the ship and from spray. Growths of (apparently) *Staphylococcus pyogenes albus* and of a yellow coccus, possibly *Staphylococcus pyogenes citreus*, were obtained, and also denitrifying organisms.

Examinations made by exposing plates and tubes in the crow's-nest at the top of the mainmast, during the same period, for as long as 20 hours, proved uniformly sterile. In winter quarters, during the winter months, agar plates were occasionally exposed for a few hours on the glacier abutting on the beach at the head of Scotia Bay. No growth was ever obtained on any of these after incubation. No air examinations were made during the summer months.

Dr Gazert, at the *Gauss's* winter quarters, examined the air indirectly by making cultures from freshly fallen snow. This was invariably found to be sterile.

Dr Ekelöf at Snowhill, by exposing Petri plates, found nearly half of his experiments sterile. Of those in which growths occurred he found on an average that a Petri plate had to be exposed for two hours for one bacterium to settle on it. He comes to the conclusion that all the organisms he obtained from the air are impurities carried into it by the wind from the soil, in which, despite the almost complete absence of organic matter, he found a fairly abundant bacterial flora.

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XI.—BIBLIOGRAPHY OF ANTARCTIC BOTANY.

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THIS list makes no pretence at being exhaustive, especially as regards sub-antarctic botany. Only the more important papers are referred to. Preliminary notices of new species are not included when later reports of collections containing them have appeared. For papers dealing with unicellular algæ, reference may be made to Dr F. E. Fritsch's paper on pp. 95–134 of this volume.

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